PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA

FOR

PROMOTING USEFUL KNOWLEDGE

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VOL. XVI. JANUARY TO JUNE, 1876. No. 97.

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A Discourse, illustrative of the life and character of HORACE BINNEY, *delivered before the Bar of Philadelphia, the Law Association, and the American Philosophical Society, in the Musical Fund Hall, on the evening of Jan.* 5, 1876.

BY JUDGE WILLIAM STRONG.

Forty years ago, in this Hall, on an occasion much like the present, Mr. Binney commenced his eulogy of Chief Justice Marshall with the following remark, "The Providence of God is shown most beneficently to the world, in raising up, from time to time, and in crowning with length of days, men of pre-eminent goodness and wisdom." The thought thus expressed is worthy of recall to-day. At intervals, all along the line of human history, and especially in enlightened communities, men have appeared, who, by their native endowments, their thorough culture, their ceaseless energy, and their moral worth, have raised themselves to a plane above that of their fellows; men who have been in advance of all their cotemporaries, and to whom the rank of leaders has been universally conceded. Such

leaders have arisen in every department of social life, in the learned professions, among the devotees to fine arts, in the regions of invention, in the explorations of natural science, in mechanical pursuits, in those of commerce, and even in the department of agriculture. Occasionally some noted one has lifted his standard of attainment higher than that of any of his predecessors, and has gone forward beyond their utmost reach. Such men are among the best gifts to the world, of a beneficent God. It is through their agency society makes progress. They lead the onward way. Their lives lend attractive force to that which is truly valuable. They present models for imitation, and their achievements stimulate to a generous rivalry. Their standard, "full high advanced," is ever visible, and it calls, with a noiseless but persuasive voice, to those who are behind to move onward. No one can overestimate the value of such a life to young men in the legal profession, if it be kept ever in view. If they have not mistaken their calling, it must win their admiration, and stir the noblest impulses of their hearts. It is a perpetual reproof of contentment with any attainments less than the highest possible, a rebuke of character and conduct unbecoming the best aims, and it gives courage for the grandest efforts.

Happily the lessons of such a life are beyond the reach of death. They are the rightful property of more than one generation. They ought never to fade into oblivion. To preserve them with gratitude for

the past and with hope for the future, is a duty which the living owe to themselves and to those who shall come after them. And this duty is best performed as a skillful painter preserves in memory the subject of his portrayal. A portrait is not a life, it is true, but it recalls a life. So a delineation of character and achievement, if it be accurate, prolongs the influences the character is fitted to exert. It is therefore in obedience to your desire to perpetuate, so far as may be, the instruction and example of a life more than commonly eminent and useful, that I am to speak to you of Horace Binney.

He was born in Philadelphia on the 4th day of January, A. D., 1780, in a house belonging to Thomas Williams, in what was then known as the Northern Liberties, and in the neighborhood of Front and Coates streets. He was of Scotch and English descent. The earliest paternal ancestor of whom he had knowledge was John Binney, who, in 1680, resided with his wife Mercy, in the town of Hull, Boston Bay, in England, and from whom he was the fifth by descent in right line. The family came to this country about that time and settled in Hull, Massachusetts. The grandfather of Horace was Barnabas Binney, a shipmaster and merchant of Boston, and his father (born in 1751,) named also Barnabas Binney, was a surgeon in the revolutionary army, attached to the Massachusetts line, whence he was transferred to the Pennsylvania line. After his transfer he settled permanently in

Philadelphia, and, in 1777, he married Mary, the eldest daughter of Henry Woodrow, a man of Scotch ancestry, a whig in politics, of great purity of character and uprightness of life. Dr. Barnabas Binney was a man of liberal education, and a graduate in 1774 of Brown University, where he attained the highest distinction in his class. Thence he came to this city, and attended medical lectures at the University, in due time receiving from it a degree. He was an accomplished "belles-lettres" scholar, and acutely sensitive to the beauties of English literature. He wrote with ease and elegance, and he cherished both the taste and the talent for poetical composition. Withal his intellectual powers were fine, and he had a strength of principle, a decision and energy of action, and a sensibility and tenderness of feeling that commanded the respect of all who knew him, and greatly endeared him to the circle of his domestic friends.

Dr. Binney's wife, the mother of Horace, was also a superior person. In many points her intellectual traits and those of her husband were much alike. She had besides a keen perception and taste for wit and humor, and a remarkable faculty for catching and imitating personal peculiarities of manner, voice, and almost of look. In the character of her mind there was a large element of the dramatic. Her manner was impressive, and she had that rare union of dignity and ease which woman alone possesses, without the appearance of effort, and which she only can teach.

At the age of six years, Horace was sent to his first school, which, for a short time, was the Friends' Alms House School, in Walnut street between Third and Fourth. Very soon afterwards, he entered the Grammar school of the University of Pennsylvania, where he remained until his father's death, which occurred in 1787. Thus early, when only seven years of age, he was left an orphan, in charge of a widowed mother. In 1788 he was placed in a school at Bordentown, New Jersey, where he continued three years, and acquired the reputation of being the best scholar in the school; beginning thus early to give promise of what he afterwards became. His attainments in knowledge of the Greek language especially, must have been remarkable for a youth of only ten or eleven years. And not only was his scholarship of an high order, but his conduct was such as to commend him to the confidence of his teachers, for he was promoted to be "guider" of boys older than himself.

Leaving Bordentown in 1791, he returned to his mother's residence, in Philadelphia, then on Market between Fifth and Sixth streets, immediately opposite the residence of General Washington, and adjoining that of Alexander Hamilton. There he frequently saw the first President of the United States, as also Mrs. Washington, who was his mother's friend, of both of whom he had perfect recollection throughout his life. There he was also a witness of the ceremonies of the day; imposing ceremonies, which were remnants of

colonial usages derived from the mother country, but which long since went into desuetude. What effect such associations and opportunities had upon his youthful mind, never wanting in a pure and generous ambition, may readily be conjectured.

In 1791 his mother entered in a second marriage with Dr. Marshall Spring, of Watertown, Massachusetts, (now a suburb of Boston,) and in 1792 he went to reside with his stepfather, for whom he ever after felt warm affection and profound respect. Soon thereafter he was sent to a boarding-school near Medford, six miles from Boston. Even then, though only twelve years old, he was prepared for admission to college, but he was considered too young to enter, and he was sent to school rather to grow older, than to increase his intellectual preparation for college life. He did not remain long at Medford, because of a conviction he had that his master was incompetent to instruct him in the Greek language. An interesting incident is related of his short school life there, illustrative of his confidence in the accuracy of his knowledge, and of his resolute adherence to that which he believed correct, even to the extent of what may be considered rudeness. On the day after his arrival at school, he was called up to recite to his new master a Greek lesson in the New Testament. He began with confidence, but he had not proceeded far when he was stopped, and told he was wrong, and what the master deemed the proper translation was given. Instead of

accepting the correction silently, he insisted that he was right and that the master was wrong. This brought immediately the rebuke, "Is this your Philadelphia politeness?" to which he replied, "It is my Philadelphia Greek, sir."

After leaving the school at Medford, he was placed in the care of a clergyman at West Cambridge, in whose family he remained until July, 1793, when he entered the Freshmen class at Harvard University, the president of which, at that time, was the Rev. Joseph Willard, D. D. and LL. D. In the autumn after his admission he unfortunately lost his mother by her death, and thus became doubly an orphan. How he acquitted himself in college is shown by the fact that on his graduation in 1797, he divided the first honor of his class with a single classmate.

It was at Bordentown and at Harvard that Mr. Binney laid the foundation on which he subsequently built his character and his fame. Protected by Divine Providence, as he was wont to acknowledge, against the perils that even then beset the paths of young men in a college course; having an ardent desire for distinction in his class, a desire which forbade any deviation from moral rectitude, and sternly resisted every temptation to indolence, or vicious indulgence; he secured for himself all the advantages of mental and moral culture, which the most advanced collegiate education in this country could then give. Through his entire college life his intercourse with the officers of

the institution was one of one uninterrupted respect on his part, and of affectionate confidence on theirs. Knowledge, of course, he acquired, but that was the least of his acquisitions. He acquired the art and the habit of study, with an unfading love for it, and this acquisition was permanent. It continued to be his delight and a great element of his power until the close of his life. Never for a moment did he make the mistake, into which so many fall, of considering the *primary* object of a liberal education to be securing a knowledge of facts, or of arts, or of sciences which might be useful in after life. This knowledge he knew would decay. He sought and he obtained the "art of all arts the best,"—that of setting the mind intently upon a subject of thought, and holding it there until the subject is thoroughly understood.

This power or art of study which he acquired during his college life, he ever regarded as his most important gain, and many years afterward he spoke of it as such. Much of what he acquired he said he had lost. His knowledge of the Latin and Greek classics, as well as of the higher mathematics, had fallen away from disuse, though he had preserved enough to assist his children in their education, "but," he added, "the ununfading art which I acquired at college was that of study, and if the acquisitions of knowledge I then made by it are faded, or fallen from the surface, * * certainly the art or faculty of study has never left me." His appetite for study while he was in college was so

great, that on one occasion, instead of going to his stepfather's, where he was always happy, he remained in his chambers in one of the college buildings during an entire autumnal vacation, and studied every day of it fourteen hours. Habits and tastes like these were his constant shield, as well as his instruments of power; and long after his graduation he was able to say, "I look back to my college life with great satisfaction. I was a fair student of everything I was required to learn, and it does not now occur to me that I ever missed a recitation, or the chapel service at six in the morning, winter or summer. * * I have no recollection that during those four years I ever did a thing to make my friends blush, and their praises when I left college gave me courage to begin my first steps in the world."

During the year immediately preceding his graduation he began to look forward to his life work. His father and his step-father having been physicians, it was to be expected that his attention would be turned to the profession to which they had belonged. Accordingly he felt a strong desire to study medicine and surgery, and he attended a course of lectures on anatomy delivered by Dr. Warren, the father of one of his favorite classmates. He also read some medical books. But his step-father earnestly dissuaded him from attempting the profession, and induced him to give up all thought of it.

After his graduation in July, 1797, he remained in

the family of an aunt in Providence, Rhode Island, about three months. During the summer and autumn of that year, the yellow fever prevailed in Philadelphia. In November he came to Philadelphia to make it his permanent home, still undecided what employment he would select, but fitted in an unusual degree to enter upon any line of life, and to make for himself a place and a name. No thought of rest or of self-indulgence after his four years of intense application, diverted him from an earnest purpose to do what he could. He had been turned away from the profession for which he had a decided preference, and to which all his reading that was not scholastic had been directed. He felt no special attraction to any other, and the uncertainty of success in the legal profession, of which he had heard much, made him hesitate to select that. Without much reflection, therefore, he turned his attention to mercantile life, and requested Dr. David Jackson, his guardian, to apply to Cunningham and Nesbit, a firm of large shipping merchants in this city, to receive him into their counting house as an apprentice. Fortunately for himself, fortunately for the bar, and fortunately for the country, the counting-room was full, and the merchants had no place for him. It was then he made choice of the legal profession, and at his instance Dr. Jackson requested Mr. Jared Ingersoll to receive him into his office as a student of law. Mr. Ingersoll consented, and thus the work of life was determined. So narrowly did he escape a calling, to which he was

apparently not best adapted, and so Providentially was he led into the profession which he subsequently so much adorned. He had no friends in Philadelphia to advise him, none, at most, sufficiently acquainted with his peculiar qualifications to advise him judiciously, though he had been told by his step-father that if he selected any of the learned professions, it ought to be the law.

Among his fellow students in Mr. Ingersoll's office were John B. Wallace, who afterwards married his sister, and John Sergeant, both young men of remarkable mental force, and of indomitable ambition, and both of them were, from the commencement of his apprenticeship, his life long friends. Somewhat later he contracted an intimate friendship with Mr. Charles Chauncey which continued unbroken until the latter's death.

How faithfully he improved the opportunities which Mr. Ingersoll's office afforded him may be inferred from what he had done in college, and may be known from what he was after his call to the bar. He had learned to study, and in study, not in mere reading, he found his chief delight. Of course to him the new science to which his attention was directed, presented attractions above everything else. His steadfast effort was to learn his profession accurately. With this he suffered nothing to interfere, and he firmly resisted all the social temptations which assail young men in large cities. He had resources for recreation within himself.

He was extremely fond of music, playing well upon the flute, and singing with great sweetness of voice. Indeed, to the last days of his life music was to him a great joy, and in the education of his children he sought attentively to give them musical accomplishments. The two years and more which he spent in Mr. Ingersoll's office were passed with great advantage to himself, and he never forgot the debt of gratitude he owed to his preceptor. In after years he paid it to that preceptor's memory in a manner that delighted the bar, and set up an enduring monument of his own respect and affection.

Having completed his apprenticeship, Mr. Binney was admitted to the bar of the court of Common Pleas on the 31st day of March, 1800, though he was then but little over twenty years of age, and at the March Term of 1802 he was admitted to the bar of the Supreme Court of the State. At the time of his admission the Supreme court consisted of Shippen, Chief Justice, and Yeates, Smith and Breckenridge, associate justices. Before these men he made his first appearance in the highest court of the State, and from them he received a kindly treatment that he never failed gratefully to remember.

In the year 1800, and through the early part of this century the eminent men who led the legal profession in the city were William Lewis, Edward Tilghman, Jared Ingersoll, William Rawle, William Tilghman, and Alexander James Dallas. To these may be added Mr.

Duponceau, distinguished especially by his knowledge of admiralty law. They were men of varied accomplishments, but they were all men of power, conspicuous in the city and throughout the State, and to them was entrusted nearly the whole of the important legal business of the community. To a young man just entering the profession, the prospect of success in obtaining employment may have seemed gloomy. The business community, who most need the assistance of lawyers, were supplied, and well supplied. There seemed to be no room for other lawyers, and those who occupied the field were too strong in themselves, and too strongly entrenched in the confidence of the public, to be displaced. In truth, however, the circumstances that might have been thought to interpose almost insurmountable obstacles to professional success were adjuvants to it. The well-prepared and ambitious young men, who, on their admission, found at the bar a body of practitioners so eminent as were those I have named, monopolizing the honors and the emoluments of the profession, were taught at once to lift their own standard high. They learned that no moderate attainments, no half-hearted efforts, no imperfect preparation would meet the necessities of their case. They grew indeed for a time in the shade, but it was a healthy shade. The exhibitions of mental power, of legal learning, and of professional skill which they constantly witnessed were instructive to them, the subjects of their thought and conversation, and incentives

to severer study. It cannot be doubted that no inconsiderable portion of the power and skill of Mr. Binney, Mr. Sergeant, Mr. Chauncey and others who honored the Philadelphia bar, and gave it a wide reputation during the first half of the present century, was due to the fact that at the commencement of their professional life, they were introduced into association with the leaders of the old bar, a body of men who would have graced Westminster Hall in its palmiest days. They may have thought their apprenticeship hard and long, but it yielded abundant fruit.

Mr. Binney was not discouraged by the outlook. With a resolute will, with patient waiting, and with unintermitted devotion to study, he bided his time—and it came. His success in obtaining employment was not speedy. For six years after his admission to the bar, he had a most meager clientage, and, as he remarked afterwards, his porridge would have been very insipid, if he had had to buy salt for it with what he made at the bar. But the time was not lost. He employed it largely in waiting upon the courts, and watching the course of trials, a practice which he afterwards often commended to young men, assuring them that, if attentive, they would learn as much in court as they could in their offices, during the same hours, and that what they learned would be more useful to them in acquiring the art of managing causes.

In April, 1804, he was married to a daughter of Col. John Cox, of Trenton, New Jersey, an efficient officer

in the quartermaster's department during the revolutionary war, and the union thus formed continued through the long period of sixty-one years, until her death.

In the year 1806 he was elected a member of the legislature of the State. He served as such, however, but a single year, declining a re-election. While he was a member, one or two memorials of the Chamber of Commerce and one for the incorporation of The United States Insurance Company were committed to his charge. These brought him into association with the merchants and underwriters of the city, and so satisfactory was his management of the trusts committed to him, that immediately after the close of his membership much professional business relating to insurance flowed in upon him. To Mr. Edward Tilghman, one of the leaders of the "old Bar," he was indebted for his launch into this department of practice. Mr. Binney has himself given an account of his start in his most interesting sketch of three of those leaders. The case committed to his sole charge by the advice of Mr. Tilghman was "Gibson vs. The Philadelphia Insurance Company," reported in 1 Binney, page 405. It was one of difficulty, and it involved the application of principles not familiar to most members of the profession even at the present day. The report shows that it was very ably argued by him, and with success. It was the second case which he argued in the Supreme Court of the State, and it was the beginning

of the large success for which he had waited so long, and for which he had made such thorough preparation. The insurance business was never, perhaps, better, at any time, or at any bar, than it was in Philadelphia, from 1807 to 1817, including the ten years between his substantial entrance into practice, and his attainment of the full reputation and employment which he held undiminished during his continuance in professional life.

In these years, pressingly engaged as he was in professional duties, he prepared and published his six volumes of reported decisions of the Supreme court of Pennsylvania, covering the period from 1799 to 1814. To this work he was invited by Chief Justice Tilghman, soon after his return from the legislature. That he received the invitation from such a source, before he had obtained any considerable practice, and when he was only twenty-seven years old, was a very high testimonial to the confidence which his abilities, his culture, his habits and his character had won for him in the best quarters. Mr. Edward Tilghman's faith in him, as exhibited in the incident to which I have referred, illustrates the respect he had gained from the leaders of the "Old Bar," whose judgment was not likely to err. Of his reports I must make only brief mention. Fortunate would it be for any court of last resort, and fortunate for the legal profession, if all reports had equal merits. Certainly throughout the six volumes the reporter gave irrefragable proofs of his

ability to comprehend legal arguments, and to restate them with clearness in a condensed form. His analysis of the facts upon which the judgments were rendered, was rigid and accurate, and his head notes expressed exactly what the court decided. No complaints have ever been made that his syllabus was not sustained by the case. When the reports came from his hands they left nothing to be desired. They must always be regarded as the work of an accomplished lawyer. It is not an easy matter to report well, and it is very rare that any reporter gives full satisfaction to the court and to the bar. The art requires not merely fairness, accuracy, and ability to comprehend what was argued and decided—it requires all that and more. It demands ability to gather from the mass of facts in the record those that really constitute the case, and to state them lucidly, omitting all that are not material, and overlooking none that are. It demands also power to extract from the opinion of the court the legal principles adjudged to be applicable to the facts, and to restate them in short, and with perfect accuracy. By the universal judgment of the profession, such a reporter was Mr. Binney. His authorship, as a reporter, ceased in 1814 on the publication of his sixth volume.

After 1807 his professional engagements were very large, not only in insurance cases, but in all kinds of important business. He seemed to pass at one bound from his long apprenticeship in waiting into acknowl-

edged leadership. He divided the business of the courts with the eminent men who, when he came to the bar, held all that was worth holding. How great his share became, and how completely he won the confidence of the business community, as well as that of his professional brethren, may, in some measure be discovered by an examination of the reported decisions of the Supreme Court of the State, of the Supreme Court of the United States, and of the Circuit Court of the United States for this district. His work appears in Binney's reports, in those of Sergeant and Rawle, Rawle, Penrose and Watts, William Rawle, in Washington's Circuit Court reports, and in those of Cranch, Wheaton, and Howard. His engagements in the local courts, and in his office were correspondingly large.

He was favored by the privilege of conducting most of his cases, and making most of his arguments in the Supreme Court of the State before a Chief Justice who presided there more than twenty years while he was in full practice, and for whose abilities and personal character he had unbounded veneration, and even affectionate regard. He knew also that he in turn enjoyed the fullest confidence of that most excellent magistrate. The advantage of such relations between an advocate and the court he addresses can hardly be over-estimated. In the Federal Circuit Court for this district, where Judge Washington presided, about thirty years, and in the Supreme Court of the United States under Chief Justice Marshall, he enjoyed similar advantages.

I do not propose to call your attention to any of the cases in which he was engaged, though many of them were of much interest. Grateful as the work would be, I have not time for its performance.

In reference to his arguments, however, I make a single remark. Some of them have been preserved by the reporters in a condensed form. To estimate them justly they should be compared with the condition of legal knowledge and legal reasoning when they were made. And when thus compared, many of them, I think, will be found to have been, in exact exhibition of legal principles, and of the reasons upon which those principles rest, much in advance of what was generally known, and in advance even of what had been expressed in judicial decision.

The war of 1812 brought with it the usual fruits of war: destruction to commerce, embarrassment to trade, rash speculation, and consequent profit to the members of the bar. Unhappily their direct interests are rarely injured by national adversity. This, perhaps, is one of the "principal deductions from the general popularity of the profession, and one of the reasons why it receives more respect than love," without fault of its own. Mr. Binney shared largely in that profit, and the close of the war in 1815, found him in possession of all that the profession of law could give to its professor, whether of reputation or emolument. The eminent leaders of the bar, whom he encountered at his entrance into the profession, had, in a great

degree, retired from active business, and, soon after, most of them departed from life. The field was clear, and, with the exception of Mr. Sergeant and Mr. Chauncey, his constant friends, he was almost without a rival. But this caused no relaxation of his energy. The habits he had formed in college, his love of study for study's sake, and his deep-seated convictions of duty to his clients, with an ever-abiding sense of obligation to them, overcame all tendency to inertness, if any ever approached him, and he continued till the close of his professional life as heartily devoted to it, and as mindful of its claims, as he was in the first flush of his manhood.

He had one cardinal principle upon which he always acted, and which he regarded as the secret of his success. It was to attend to no calling but his profession, knowing that if that were attended to, it would do all for his family and enough for himself. He listened, no, not for a moment, to any invitations, (and many were given him,) to speculate in stocks, or in real estate, or to take part in any kind of trade. He felt it impossible for him to do so without neglecting the practice of the law, which, if faithfully pursued, he was assured would be better than any, or all things else. Guided by this principle he resisted calls to public life. Before he was fifty years old, he had been twice offered a seat on the bench of the Supreme Court of the State, and once, at least, if not twice, he was tendered a commission to be a judge of the Supreme Court of the

United States. All these offers he promptly declined. It was not because he did not value distinction, and not because he did not know his own superior fitness for the posts offered, but he valued excellence above place, and his chosen road to excellence was the path he had marked out for himself at the commencement of his career.

Yet, though he would not suffer himself to be diverted from entire devotion to his profession by office, or by seductive hope of gain in other directions, he did not decline calls that he thought consistent with that devotion. In 1808, when only twenty-eight years of age, he was chosen a director of the first bank of the United States. This appointment he accepted, and he continued to act as a director and a trustee very many years. It was in the service of the bank he argued his first case in the Supreme Court of the United States. The case was The Bank vs. Deveaux et al., reported in 5 Cranch, page 61. No one can read his argument, condensed as it is in the report, without admiring its orderly arrangement, its reach and its logical power. It was the effort of a lawyer well trained and well furnished.

In 1827, Chief Justice Tilghman died. He had in 1806, succeeded Chief Justice Shippen in the headship of the Supreme Court of the State, and he remained its head during the long period of twenty-one years. It was under his administration that the law of the State had grown into an orderly and well adjusted sys-

tem, that the common law of England had been accommodated to the novel circumstances of our people, that the land laws of the State had been reduced to an intelligible code, that our mingled system of law and equity had been developed, and that many of the most important rules of property had been established. To the work of educing such results he was admirably adapted by the structure of his mind and its high culture, by his wise and broad common sense, by the comprehensiveness of his views, by his conscientious devotion to his official duties, and by a purity of character that never bore a spot. He was a man after Mr. Binney's own heart. They were kindred spirits. Under his administration of the law, Mr. Binney had grown into all his greatness and fame, and he felt, as few could feel, how great a debt of gratitude the bar and the state owed to the memory of the deceased magistrate. No wonder then, that, when invited by the bar to pronounce an eulogium of the Chief Justice, he poured out from a full heart, and from the stores of an accurate and discriminating observation, the remarkable discourse contained in the 16th volume of Sergeant & Rawle's Reports. It was not the utterance of respect and affection alone. The discourse exhibits a careful analysis of intellect and character, a just appreciation of what gave to the Chief Justice his power and his usefulness, and an admiring estimate of his moral worth. It is a photograph of that great and good man so life-like that it cannot deceive, so deeply

wrought that it cannot fade, and rendered doubly attractive by the inimitable style in which it was executed.

About the year 1830, after severer exertions than were usual, Mr. Binney's health began to be impaired, and he desired to withdraw gradually from the courts, and throw off, in considerable measure, the load of business with which he was oppressed. It was this, in part, which made him willing to accept a nomination for Congress. There were doubtless other reasons that influenced him. Principal among these was the hostility of President Jackson to the Bank of the United States. His veto of the bill for its recharter in 1832, aroused the deepest feeling of its friends, who then constituted most of the business community of this city. Mr. Binney was one of the number, and his transcendent ability, together with his well-known knowledge of the condition and operations of the bank, pointed him out as the best man to defend the institution in Congress. All eyes turned to him, and his services were at once demanded. Believing as he did in the great usefulness of the bank, and in its necessity for the public welfare, he did not feel at liberty to decline the call. He was elected, and he took his seat as a member of the twenty-third Congress on the 2d of December, 1832. That Congress was filled with distinguished men, many of them, longed trained in the public service. Mr. Binney took into it a great reputation, such as few lawyers ever brought into Congressional life. Much was expected from him, and all

that was expected was realized. If he found any equal, he found no superior. He never stooped to the arena of partisan discussions, but in the consideration of important subjects, especially that of the removal of the public deposits from the Bank of the United States, he proved himself to be a statesman of high rank, and a most accomplished debater. Though but two years a member, he has left at Washington a most enviable reputation. The old men who naturally recur to olden times, speak of him as one of the giants of the past, and worthy to be associated as a statesman and an orator with the triumvirate that so long adorned the American name.

But public life was extremely distasteful to him. He turned his back upon it with gladness. "Public reputation," said he, "is generally empty, and oftentimes false, but the respect and affection of one's own kindred and personal friends, ah! that is delightful." Declining a re-election, he returned to Philadelphia, and retired from all professional practice in the courts. In the year 1836 he went to Europe because of the ill health of a member of his family, and only once thereafter did he ever appear in any court as an advocate or a counsellor. He continued, however, to give opinions in his office until 1850. Many of these opinions, written by him, are still in the hands of members of the bar, and they are preserved with almost religious care. They relate to titles to real estate, to trusts and uses, to commercial questions, and to all

questions in every department of the law, that are most intricate and difficult of solution. They are model exhibitions of profound and accurate knowledge, of extensive research, of nice discrimination, and of wise conclusion. They have been generally accepted, as of almost equal authority with judicial decision, and not unfrequently, a claim set up with confidence has been abandoned when it became known Mr. Binney had given an opinion adverse to it.

In the year 1835 he was invited by the Select and Common Councils of the city, to deliver a discourse on the life and character of Chief Justice Marshall. That distinguished magistrate had shortly before gone down to his grave, full of years and of honor, and had left behind him a nation of mourners. He was appointed Chief Justice of the Supreme Court of the United States, by President Adams, in January, 1801, and he continued to preside in that Court during the long period of thirty-four years.

Providence smiled upon our infant nation when he was appointed. The Constitution was then an untried experiment. It had no precedent. It remained to be interpreted, and what principles of interpretation ought to be applied to it, whether a strict or a liberal construction should be adopted, or whether a more rational view should be taken of it, one neither strict nor liberal, but consonant with the paramount intent of those who framed it, and necessary to secure the objects for which it was designed, remained to be determined. It

was quite possible to make a mistake, and mistake might have brought early shipwreck to our institutions. Happily, Chief Justice Marshall proved himself equal to the demands of the time. Aided by associates, themselves able, but who deferred much to his judgment, he laid down principles for constitutional construction which have made our government what it is; which have been accepted since his death without question, and which have given stability and efficiency to the Federal Union. With sufficient knowlege to meet the necessities of his position, with powers of reasoning of the highest order, with a comprehensiveness of view rarely equalled, and with a patriotism that never faltered, he met the questions presented, and did his great work. To use the words of Mr. Binney, "He looked through the Constitution with the glance of intuition. He had been with it at its creation, and had been in communion with it from that hour, * *. Both his judgment and affections bound him to it, as a government supreme in its delegated powers, and supreme in the authority to expound and enforce them, proceeding from the people, designed for their welfare, possessing their confidence, representing their sovereignty, and no more to be restrained in the spirit of jealousy within less than the fair dimensions of its authority, than to be extended beyond them in the spirit of usurpation. These were his constitutional principles, and he interpreted the Constitution by their light." The life and services of such a man were a theme worthy of Mr.

Binney's powers. How well he performed the duty assigned to him, I need not say to the bar of this city who heard him, or who have read his discourse. He performed it "con amore." He knew the Chief Justice well. He accorded with him in his principles, admired his private character, and reverenced his judgments. In him he found powers and principles like his own, and by his eulogy he spread, in clearest light, before those who heard him, the qualities of mind and heart that made the Chief Justice both great and good. He depicted in unfading colors what the great magistrate had done, and held him up to that age and to all future time as an immeasurable benefactor to the country.

In 1844, by appointment of the City Councils, Mr. Binney argued in the Supreme Court of the United States, the case of Vidal *et al. vs.* Girard's executors (reported in 2 Howard, p. 127), in which was involved the validity of the trust created by Mr. Girard's will for the establishment and maintenance of a college for orphans. The case had been argued at a previous term, by Mr. Sergeant, and it is said that, discouraged by the apparent uncertainty remaining in the minds of the judges, he asked for a re-argument. Whether this was so, or not, a re-argument was ordered, and Mr. Binney, though years before he had withdrawn from the state courts, accepted the appointment of the City Councils, and argued the case anew. Of his argument I have no space or time to speak as it deserves. The

remembrance of it lingers around the court room until this day. It is in print, and it has ever been the wonder and the admiration of the legal profession in this country, and almost equally of the profession in Great Britain. It lifted the law of charities out of the depths of obscurity and confusion that covered it before, and while the fullness of its research and the strength of its reasoning were masterly, it was clothed with a precision and beauty of language never surpassed. No wonder it was successful. It was a fitting close to a long and pre-eminent professional life. Mr. Binney never afterwards appeared in court, though he continued for some years to examine legal questions submitted to him, and to give written opinions. At length the calls upon his attention became so numerous as to be oppressive. The examinations they required were trying to his eyes, which after 1832, frequently suffered from inflammation. For these reasons, in 1850, he withdrew entirely from all professional labor. Thus relieved, his eyes recovered their strength, in good measure, and they continued to be of service to him ever after.

But, with leaving the profession, he did not abandon his habits of study. Released from the demands of a jealous and laborious pursuit, he turned with new zest to what had ever been to him a delight. He always had a vigorous appetite for the best literature, especially for that which was moral and religious, and this appetite increased as he grew older. He was a good

Spanish scholar, and proficient also in the French language. Books in both French and Spanish he was fond of reading, as also History, Metaphysics, Poetry (especially dramatic poetry), and Theology. Of the latter subject he was a close student. He was a firm believer in the truths of divine revelation and an habitual reader of the Bible. He carefully read also many of the most important opinions of the Supreme Courts of of the State and of the United States, and some English decisions. He kept himself well informed of the current events of the day, and in regard to all public questions that agitated the city, the state, or the country, he not only sought information, but he matured settled opinions. To such employments he devoted mainly his time and attention after his complete retirement from professional life. Many years afterwards, when speaking of this period of retiracy, he said "his objects had been, *first*, to keep himself from rusting out by such occupations intellectual and bodily as would keep him in reasonable tune, while the decays of age were gradually impairing the old sounding board, *second*, to continue useful to his family, as it was arriving at years of maturity, and would look for settlement in the world, *third*, to be useful to the world, so far as should be in his power, without becoming denatured, by a public part in the various avocations, religious, literary, social, political, philanthropical, national and municipal which distinguished the times from those which preceded them, and, *fourth*, to prepare for the

final event, by availing himself of all the means which God had graciously vouchsafed to him." "Progress in this sense," he added, "is private, public, temporal, eternal;" "spreads undivided, operates unspent," "comprehends the performance of all duties in such measure as is consistent with all, and ends in that perfect stature which all should endeavor to obtain, though so few attain to it."

The activity of his mind remained undiminished until his death. He was constantly occupied, though not always, in the indulgence of his fondness for reading and study. Occasionally he made a rich contribution to the enjoyment and instruction of the public. In 1849, at a meeting of the members of the bar, convened after the death of Mr. Chauncey, and at a similar meeting in 1852, soon after the decease of Mr. Sergeant, he gave utterance to his estimate of those distinguished men, with remarkable analyzation of their mental and moral characteristics, and in words all aglow with the warmest friendship. The meeting in reference to Mr. Sergeant's death was the last occasion of his distinctive association with his professional brethren. He never again appeared at a bar assemblage. Once only afterwards, (so far as I have learned,) did he allow himself to be prominent on an entirely public occasion. It was on the 22d day of February, 1860, when in response to an invitation of the City Councils, he read before those bodies assembled in joint meeting, Washington's Farewell Address. In

addition to the members of the Councils, a few invited friends were present. Mr. Binney, then eighty years of age, stood on the platform in the Common Council chamber, and read the entire address, with a firm voice, and with expressive emphasis. When he had concluded, silence ensued in the chamber, the audience evidently expecting some remarks from him. He was much affected, and after pausing awhile, he said, "and thus closes the noblest compendium of fatherly affection, patriotism and political wisdom the world has ever seen. No words of mine are fit to stand beside it." In the year 1852, at the one hundredth anniversary of The Philadelphia Contributionship for the insurance of houses from losses by fire, he delivered an address on the history of fire insurance, and upon the principles adopted by that association. Like everything which came from him, the address exhibited the completest understanding of his subject, great felicity in its mode of presentation, and a vigor and beauty of expression unsurpassable. It is read with pleasure and with profit even now. In the following year he published a valuable and suggestive article on the naturalization laws. In 1858 he gave to the public a sketch of the life and character of Bushrod Washington, a Judge of the Supreme Court of the United States, who for many years presided in this circuit with great honor to himself, and usefulness to the country. In his court, Mr. Binney had very constantly appeared, in the conduct of most important causes, and there had

grown up between the Judge and the lawyer mutual regard, and even affectionate admiration. These feelings and sentiments found unrestrained expression in the sketch, and therein also, he delineated, with his wonted acuteness, the qualities which make up a perfect *nisi prius* judge, nowhere else better, if as well, described.

In the same year (1858) he published those exquisite descriptions of three leaders of the old bar of Philadelphia, which are still read in this community with intense interest, though the men described belonged to a generation long gone past. The freedom of the writer from all envy or jealousy; the generous appreciation and acknowledgment of true and varied excellence; the searching analysis of intellect and character, and the graceful presentation of each subjects individuality which the descriptions exhibit, have compelled admiration alike in this country and in England where they were reviewed by Sir John Coleridge, with expressions of warm admiration alike of the sketches, and of the author.

In 1858, also, he gave to the press a more extended discussion, entitled "An inquiry into the formation of Washington's farewell address," which is not only curious and interesting, but strikingly illustrative of the character of his mind, and of his habits of thorough investigation, and of reasoning. It is mainly a treatment of evidence, coupled with a description of conflicting probabilities. From it one who never knew him in the

exercise of his profession, may learn how careful and minute was his search after facts, how calmly and wisely he arranged every fact discovered in its proper relation to all others, giving to each its due weight, how inevitably his deductions seemed to flow from his premises, and how precise and perspicuous was the language he employed. No one, I think, can rise from its perusal without a thorough conviction that its conclusions are absolutely correct, and that the opinions that prevailed before its publication were, all of them, more or less, erroneous.

One other product of his thoughts he gave to the public. During the progress of the civil war, the President of the United States, under the pressure of what seemed a real necessity, suspended the privilege of the writ of *Habeas corpus*, without any authority given by Congress, claiming that by the Constitution, and from the nature of his executive office he was invested with the power to suspend the privilege, in cases of rebellion or invasion. As might have been expected, his act immediately called forth much unfavorable criticism, and his power to do what he did, in the absence of Congressional authority, was in many quarters, strenuously denied—in all quarters, perhaps, at least doubted. It was then (in 1862) that Mr. Binney turned to the consideration of the subject, and gave to the public an argument in support of the power claimed by the President, not less remarkable than the best of his earlier efforts. This is not a proper occasion to pronounce

judgment upon the correctness of his conclusions. Of the argument itself, however, I may speak. It was thoroughly original, and it was constructed with a force and elegance that won admiration, even where it did not command assent. It is contained in three pamphlets published successively in 1862, and 1863. They will never cease to be regarded as models of acute reasoning applied to constitutional law.

To such labors and employments Mr. Binney devoted the later years of his life. They were happy years, crowned with habitual cheerfulness, though not unmingled with sorrow. In 1865 Mrs. Binney, his companion through all his early struggles at the bar, and through the period of his highest success, was removed by death. And in 1870 he suffered another severe affliction in the death of his oldest son, Horace Binney, Jr. That son was himself pre-eminent in mental and moral culture, in soundness of judgment, in refinement of taste, in goodness of heart, in true piety, and in all that adorns and ennobles human nature. The father and the son were companions to each other, kindred in spirit as well as in blood. Their mutual confidence was perfect, and consequently their intercourse with each other was a source of intense happiness to both. This was but a natural result of the attention the father had given to the son's training. During the four years the latter was in college, the closest intimacy was kept up between them by a weekly, and at times, a semi-weekly correspondence, in which the father encouraged the

son to perfect confidence in him, and in return gave the benefit of his counsel with a loving interest. The correspondence was never permitted to flag, though Mr. Binney was then at the height of his professional practice, bearing a heavy pressure of business both in and out of court, and superintending a large class of law students, whose examinations he always conducted with regularity and strictness. It was guided by his advice, and in the light of his example and character that the son grew into full manhood, and in the later years of his life the relations between him and his father became more than filial and paternal. They were almost fraternal. The father leaned upon the son, reposed full confidence in him, regarded him as his strongest earthly prop, and looked to him as the one to fill his place after his own last summons should come. How great the sorrow which the son's unlooked for removal, in the fullness of his usefulness, and of the high estimation in which he was held by the community, must have brought to the father's heart cannot be told. Mr. Binney was then more than ninety years old. The shock of such a bereavement might well have been fatal. But the blow did not crush him. He felt it most keenly, but with submission to the will of Divine Providence, he resolutely addressed himself to the new and unexpected duties cast upon him. These having been performed, with his attention more and more turned toward the final event that awaited him, and with a cheerfulness of dis-

position that knew no abatement, he continued to live in the midst of his books and his thoughts, the delight of his family, and the charm of all those who enjoyed intercourse with him until the 12th day of August 1875, when he peacefully passed from this life into a world where his splendid intellectual powers will forever expand, and where his moral excellence will never cease to grow.

His death occurred forty years after the age when most men are at the zenith of their reputation; forty years after he had substantially withdrawn from public view and from active participation in all matters that attract general notice, and at the end of a period when public recollection of most lawyers has faded into indistinctness, yet it would be difficult to mention a death that caused a sensation more wide spread and profound than his. Not alone in this city, or in this state was it felt that a great luminary had been extinguished, but the legal profession of the whole country acknowledged the bereavement, and many unprofessionals hastened to declare their loss.

I have thus given an outline of the life and labors of this remarkable man. In looking over it I see there is much that ought to be filled in, and some things that deserve particular notice.

He was a most accomplished lawyer. This, perhaps, might have been expected from his mental endowments, and from the habits of study that he acquired in early life. But he surpassed expectation. I

know of no language which so aptly describes him as that which he applied to Mr. Edward Tilghman, the friend of his youth: "He was an advocate of great power; a master of every question in his causes; a wary tactician in the management of them; highly accomplished in language; a faultless logician; a man of the purest integrity and the brightest honor; fluent without the least volubility; concise to a degree that left every one's patience and attention unimpaired, and perspicuous to almost the lowest order of understanding, while he was dealing with almost the highest topics."

He had great advantages, none of which were neglected. Besides the opportunities his collegiate course afforded him, and which he improved to the uttermost, besides the art and habit of study he early acquired, he had examples of excellence before him which it was not in his nature to disregard. He was trained to be a legal tactician by his constant attendance in the courts before he was called to assume the management of causes. He thought logically and spoke and wrote the purest of English before he came to the bar. He had a fine commanding person, an uncommonly handsome face, a dignified and graceful manner of address, and a most melodious voice, perfectly under his control, and modulated with unusual skill. He was constitutionally an earnest man, yet while earnest, he had a calm self-possession, the fruit of consciousness that he fully understood his subject, and of confidence that he could make

others understand it, and he entered upon the trial of his causes with a sure conviction, confirmed by his previous study, that he was advocating the right. No unjust or dishonest case would he willingly undertake, and he was able to say after his career at the bar had closed, that "he had never knowingly committed an injustice toward a client, or the opposite party, or prosecuted a cause that he thought a dishonest one, and that he had washed his hands of more than one that he had discovered to be such after he had undertaken it, as well as declined many which he perceived to be such when first presented to him." Add to this the power of a mind equal to the comprehension of any legal subject; a mode of presentation the best possible; a rhetoric that was faultless; an aptness of illustration that illuminated the most abstruse matters; a personal character without a visible flaw, and it is easy to see he must have been, as he was, a most persuasive and convincing advocate.

He won the confidence of courts and juries by his entire freedom from trick, or any of the low arts of cunning. He disdained to practice any stratagem or artifice for the purpose of obtaining an advantage over an adversary. His nature was true, and his life was truth unfolded. He was always candid, giving full consideration to whatever made against him. He appealed to no prejudices, but rather boldly met, and endeavored to dissipate them. He was ever courteous in his demeanor towards the court, and towards his op-

ponents. Thus every element of power, in mind, in culture, in habit, in physical endowment, in taste, in demeanor, and in character, was his. All united in giving to his forensic efforts an efficiency, and a success inferior to those of no other. Our brethren that remain, who saw him at the bar, speak of him as ever maintaining a dignified decorum, and a manner not reserved or cold (though perhaps apparently such at times), but genial and good humored toward his professional brethren, and respectful to the bench. They speak of him as above the suspicion of rhetorical arts, or partisan strategy. They say his appeals were to the judgment rather than to the passions; that his action was graceful; that he never sought to make a display of oratory though he was always eloquent in thought, and winning in diction. He was never heard without instruction, never without pleasure.

He had some other characteristics that deserve special mention. In everything he undertook he was thorough to the highest degree. Thoroughness was a habit of his life. He brought it to all his investigations, and he regarded it as a duty never to be slighted. In his view it was criminal to neglect the fullest possible preparation for the trial of every cause committed to his care, or for any opinion he was called upon to give. One of his maxims, often commended to others, and always acted upon by himself was "Work up to power." Whatever came from him was, therefore, the best he could produce, and those who

followed him rarely found any thing that had escaped his notice, or his thought. What he did not make use of was, in his judgment, of no importance, and therefore entitled to no consideration. It was not unnoticed because unknown. And it was never safe to treat as of little worth any position he took. His mind at once seized all the facts and the principles applicable to them, and discarded all that, after careful thought, he deemed immaterial, or inapposite. He was never surprised by any thing against which the extremest vigilance could guard. Hence nothing immature, nothing unfinished ever came from him in argument, or in essay. Nor was he thorough only in his profession. He carried the habit into his general reading, both literary and scientific. Whatever he knew, he knew throughout. No chamber of it, however remote, escaped his exploration. He gathered from every book he read all the thoughts worthy of being preserved, and made them subjects for his own reflection, recurring to them from time to time for renewed consideration.

His reading was so extensive that he made constant use of helps to return to passages which had most interested him. He was therefore a great admirer of a good index. I say index, not digest. His estimate of such an index was expressed in a letter to a friend, written when he had passed his eighty-sixth year, wherein he said: "I must say in reference to indexes generally, that I have come to regard a good book as curtailed of

half its value, if it has not a pretty full index. It is almost impossible without such a guide, to reproduce on demand the most striking thoughts or facts the book may contain, whether for citation, or further consideration. If I had my own way in the modification of the copyright law, I think I would make the duration of the privilege depend materially on its having such a directory. One may recollect generally that certain thoughts or facts are to be found in a certain book; but without a good index such recollection may be hardly more available than that of the cabin boy, who knew where the ship's tea kettle was, because he saw it fall overboard. In truth a very large part of every man's good reading falls overboard, and unless he has good indexes, he will never find it. I have three books," said he, "in my library which I value more than any other three, except the very books of which they are a verbal index; Cruden's Concordance of the Bible, Mrs. Cowden Clark's Concordance of Shakespeare, and Prendergast's Concordance of Milton." The estimate of good indexes thus expressed illustrates how earnest was his search for truth and knowledge, and how reluctantly he let go any of his acquisitions.

Mr. Binney's thoroughness was accompanied by strictly methodical habits. He had a place for every thing and everything had its place. The arrangement of his briefs, of his papers and books, and equally of his stores of knowledge and thought was perfectly systematic. It was this that enabled him ever to pro-

duce on call, the facts of which he had acquired knowledge, and the thoughts he had matured, together with the illustrations needed, and to fortify what he produced by apt quotation of authorities.

Of his judgment, I find it difficult to speak in fitting terms. It seemed to be intuitive, yet its conclusions were cautious deductions of sound reason from a most comprehensive and accurate view of the facts, alike in detail, and as a whole, and from a wise selection of the principles properly applicable to the state of the facts as he found them. He brought to every subject submitted to him the calmest consideration, unbiassed by prejudice or pre-conceived opinions, and he gave true weight to whatever bore upon it. Hence the decisions of his judgment were never narrow, and almost never wrong. He was a most wise and safe counsellor at the bar, and in every circle where his counsel was sought.

He was a man of great moral courage. When he had matured his convictions of the right, he was not to be driven from their avowal by any fear of consequences. He was a resolute and fearless supporter of law and order in the community. When the Kensington riots threatened to uproot the foundations of society in the northern part of the city; when the law was temporarily overthrown, and its officers were powerless to resist the outbreak; when "men's hearts failed them for fear," and many thought only of submission or compromise, he stood firm. He bent not be-

fore the storm. It was he more than any other who inspired confidence. It was he that restored courage to many who were faint-hearted; that gathered around him the virtue and intelligence of the city, and led in bringing back the supremacy of the law. And when, in later years the foundations of our government seemed crumbling away; when civil war threatened the subversion of our cherished institutions; when attachment to party, with very many, prevailed over love of country, Mr. Binney, an old man of more than fourscore, stepped forward, and placed all his influence and the weight of his great name in the scale of a tottering government. Nor was there ever an occasion when high moral courage was demanded, when the city was in trouble and needed a leader and adviser, that he was called upon and failed efficiently to respond. He was often resorted to in seasons of perplexity, and never was application made in vain. Even when not consulted, the friends of good order, and of the right were encouraged by the fact, of which they needed no other evidence than his life, that he would always be found on the side of the just, the orderly, and the true.

Though he was not long in official life, he gave the fullest proofs that he was both a patriot, and a statesman of high order. The evidence is to be found in the opinions he expressed in Congress, and in those which from time to time he gave to the public while he was in private life. He understood thoroughly the organi-

zation and action of both the State and General Governments, and he was familiar with the whole science of constitutional law. He was in the main a conservative, though not averse to healthy progress. According to the division of parties existing soon after the adoption of the Federal constitution, he was ranked as a Federalist. He adopted the views of the constitution held by Washington, Hamilton and Marshall. To these he adhered during his life, and he made no secret of them when they became unpopular. On the 14th of January, 1872, when writing to a friend, he said: "You know I am the residuary legatee of Washington Federalism. I am not, however, without a great many younger men who are *haeredes instituti*, though *post nati*." But, though a conservative, he approved of changes that he thought improvements. He did not think all changes progress, though he recognized that progress means change. He conceded that the advance of civilization demanded a change of laws in many particulars, and of organic law in some. Still he was not a friend to any changes hastily made; changes that might bring evils in their train not less than those they were intended to cure. Not lacking confidence in the masses of the people, he yet thought it a great mistake to subject the judiciary to dependence on a popular vote. With a high estimate of its importance to the stability of our institutions, and to the correct administration of law between man and man, he deprecated every scheme that threatened diminution to its

independence, and tended to drag it down into the mire of party politics. He favored the consolidation of the City of Philadelphia, as tending, in his judgment, to the promotion of good order, and to the general reform of subsisting abuses, and he lent his influence to send to the Legislature the men of "experience in civil affairs, of general knowledge, talents, integrity, moral courage and conscientiousness" through whose agency consolidation was effected.

Immersed as he was all his life in a flood of occupations, and unwilling while he was engaged in the practice of the law, to be diverted from it by any hope of gain to himself, he felt a deep interest in many institutions cherished by the community, and in many of our noblest charities. He was one of the originators of the Academy of Fine Arts, and with forty other members of the bar he signed the articles of association. William Lewis and Judge Tilghman were also among the signers. Mr. Binney was the youngest. He was present at the first meeting in the Hall of Independence, to choose officers, and to launch the constitution of the society, and there he made an address. He was early connected with the Horticultural Society, and he was a member of the Franklin Institute and of the American Philosophical Society. He presided many years over the Apprentices' Library Company. He was long a director of the Pennsylvania Institution for the deaf and dumb, and he was a contributor to the House of Refuge. He felt great interest

in savings institutions, and in all agencies adapted to promote the thrift and comfort of persons in humble life, and he was associated with other public charities. He was also deeply interested in the benevolent institutions of the Church, to which he belonged, giving to them much of his time, his matured wisdom, and his pecuniary support. The most delicate, refined, and unostentatious charities seemed most to enlist his sympathies. He was a member of the corporation for the relief of the widows and children of clergymen in the communion of the Protestant Episcopal Church from 1831, until his death, and much of the time its President. To it, and to all other associations with which he suffered himself to be connected, he gave much more than his name. He gave his sound judgment, his wise counsels, and, whenever needed, his labor and his money. Their records are full of the evidences of his efficient services, and the touching minutes adopted by them after his decease, attest the value of his co-operation, and the strong hold he had upon the reverence and affection of his associates.

Mr. Binney's friendships were warm, and they were lasting. No envy or jealousy interfered to disturb their harmony. If ever broken, it was because his confidence was necessarily withdrawn. His addresses after the death of Mr. Chauncey, and Mr. Sergeant bear witness to the intensity of his affection for those friends, though more than all others, they had been his

rivals, and often opposed to him in the strife of the bar. In the last year of his life he said in a letter to a life-long friend "my wishes for your happiness are as constant as the return of my days." The tenderness of his love for children was remarkable, and it was often demonstrated. His affections never ceased to flow in warm currents towards the descendants of the friends of his youth, and he found some of his choicest pleasures in contributing to their happiness. His letters abound in outgushing sympathy with the joys and sorrows of the young, as well as with those of his older friends.

Of the light he was in his own dwelling, of the wealth of affection he exhibited there, and of his devotion to the happiness and to the mental and moral culture of his children, I will not speak.

He was an admirable conversationalist and correspondent. His mind and his memory were so full of the richest thoughts that they overflowed into his conversation and into his letters of friendship, and his power of expression was so ready and so chaste, his pleasantry was so genial, and his moral sentiments were so pure, that those who enjoyed correspondence with him will ever preserve his letters among their treasures.

It would be interesting to speak of the stores of observation gathered into his memory during his long life, and ready for his recall. He lived more than ninety-five years and a half, longer than any celebrated

lawyer of whom I have knowledge, either in this country, in Great Britain, or on the continent of Europe. He lived with unimpaired mental faculties, and generally in the enjoyment of good health, preserved and confirmed by temperate habits and regular bodily exercise. His adult life extended over the first three quarters of the present century, a period of advance, not of retrogradation. In it the world saw most remarkable changes. Empires rose and fell. Many new kingdoms and governments were established. Constitutional law made wonderful advances, and municipal law was accommodated to an altered condition of human affairs. The mechanical arts made unprecedented progress. New powers and agencies were discovered, more potent than any before known, and applied to daily use. Religious toleration advanced to be an accepted doctrine, and popular education came to be regarded as of inestimable importance. Society in very many particulars, was revolutionized, and civilization achieved greater triumphs than in any former equal period of the world's history. Of all these changes Mr. Binney was an attentive observer. It was not in his nature to be indifferent to them. He not only noticed the progressive changes, but he must have considered their causes, and their probable consequences. He was himself a link that connected the men of the revolution with the present generation. What an ocean of thought the events and changes of his life-time spread out before his declining years! And

how suggestive the memories must have been! But I may not pursue this speculation.

One other and the crowning glory of his life and character remains to be mentioned. He was an earnest Christian. I have already said he was a close student of Theology, a firm believer in the truths of Divine Revelation, and an habitual reader of the Bible. His confidence in the Divine inspiration of the Bible began in his youth, and gathered strength with his increasing knowledge of what it contains. He was a consistent member of the Protestant Episcopal Church, and he carefully trained his children to the reverence and love he had for its liturgy. For many years he was a leading member of Episcopal Conventions, and he made himself greatly useful in them. He was more than a Church member and a Church officer. He carried his religion into his daily life. It was a controlling power in his business, in the formation of his judgments, and in his intercourse with others. It was the basis of his fidelity to his clients, and of his unwillingness to do injustice to opponents. It led to the courtesy of his demeanor, and to his habitual candor. It contributed also to his personal enjoyments. He found great satisfaction in the study of religious books, especially those relating to doctrinal theology. "He loved to bring his reason to the support of his faith, and he delighted in the most cogent arguments in support of Christianity." His mind was at all times a reverent one. He discountenanced, systematically, in

his household, all conversation and every allusion that looked like irreverence on sacred subjects. More than once he brought the fine powers of his mind to the elucidation of Gospel narrative, and on one occasion he charmed his family and near friends by an essay written in his leisure moments, in support of his own view of a much debated religious question. There dwelt within him habitually a serious conviction of personal responsibility, that led to a high estimate of the value of time, and he was rigid in his self-examination. At one time, near the close of his life, when speaking of his debility, he said, "but I do not think that I have gone back, and I am very thankful for it, because a single step backward would, I think, have finished my *sum* and it must have been shown as it stood on the *slate*, right or wrong, to the Great Master. I hope that what is wrong in the *sum* may prove to be written on *slate*, that Mercy may pass her soft and gentle hand over it. But there is something which no touch will remove, because it is not *there*—THE GOOD I HAVE NOT DONE."

His faith was a support and consolation to him in the times of his great sorrow. It gave him infinite comfort when his son Horace was removed by death. Indeed the strongest bond of union between the father and the son was, at all times, the assurance they felt of their common confidence and trust in the Triune God, and that trust was the father's anchor when the waves of sorrow went over him. It never failed him. His last days were illumined by a calm reliance upon

his Redeemer, and by a perfect willingness to meet the final summons whenever it might come. Doubtless he was found watching. The books which he read and actually studied during the months of June and July immediately preceding his death were "The Philosophy of Natural Theology," an Oxford Prize Essay, written by the Rev. William Jackson, in confutation of the scepticism of the present day, and "The Unseen Universe," or "physical speculations on a future state," both of them works of deep-toned piety, as well as of great research. They cannot be read without close attention, and intense thought.

I feel that I ought not to detain you longer, though very much of great interest remains unsaid. *After all*, Mr. Binney's powers and character are best illustrated by his life. That was singularly consistent and complete. It is safe to say that rarely if ever, has a man lived who had fewer apparent defects From whatever point of human view he was observed, no flaw or imperfection was visible. In every aspect, he was symmetrical, with no faculty undeveloped or distorted, with not even an excellence overgrown at the expense of any other—throughout both great and good.

Such was Mr. Binney. So during three generations he stood erect and conspicuous among his brethren of the bar, and in this community, a light and an ornament—a strong tower and a ground of trust,—a leader and a guide.

Stated Meeting, January 7th, 1876.

Present, 13 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters of acknowledgment were received from the R. Observatory at Prague, Oct. 13, (92); Bavarian Academy, Nov. 1, (92, 93); Holland Society at Haarlem, Aug. (92); L. and P. Society at Liverpool, Dec. 3, (93, 94); Anthropological Institute of Great Britain, Dec. 15, (XV, ii, 93, 94); and the New York Lyceum of Natural History, Dec. 28th, (XV, ii, 94).

Letters of envoy were received from the C. P. Observatory at St. Petersburg; C. Bureau of Statistics, Stockholm, Sept. 20; Bavarian Academy, Munich, Nov. 1; Haarlem Society, Jan. 20; L. and P. Society, Liverpool, Dec. 3; and Board of Commissioners of the Second Geological Survey of Pennsylvania.

Donations for the Library were received from the Bureau of Statistics at Stockholm; International Congress of Geography of 1875, at Paris; Prague Observatory; Geographical Society and Geological Institute at Vienna; Imperial Academy and Geological Society at Berlin; Zoological Gardens at Frankfort; Holland Society at Haarlem; Dr. Jos. B. Davis; R. Institute of Lombardy; Venetian Institute; Geological Committee at Florence; Academia dei Lincei, and Pontifical Academy at Rome; Observatory at Naples; Anthropological and Geographical Societies at Paris; Annales des Mines; Nouvelles Météorologiques; Revue Politique;

M. L. Hugo; Physical Society at Bordeaux; Astronomical, Chemical and Zoological Societies at London; Nature; Gen. Sabine; Silliman's Journal; Prof. Frederick Prime, Jr.; American Chemist; Penn Monthly; Journal of Pharmacy; Geological Survey of Pennsylvania; U. S. Department of the Interior, and Mexican Geographical and Statistical Society.

A set of photographs of ornaments on the Public Buildings were presented by Mr. McArthur.

The Committee on Dr. Valentini's paper reported progress and was continued.

The death of Dr. Wm. Böckh, at Christiania in Norway, Dec. 10, 1875, was announced by letter.

Prof. Houston communicated his views regarding the so-called "new force" claimed to have been discovered by Prof. Eddison of Newark, N. J.

The report of the judges and clerks of the annual election was read in its usual form, announcing as the officers of the ensuing year:—

President,

George B. Wood.

Vice Presidents,

John C. Cresson, Isaac Lea, Frederick Fraley.

Secretaries,

E. Otis Kendall, John L. LeConte, Pliny E. Chase, J. P. Lesley.

Curators,

Joseph Carson, Hector Tyndale, C. M. Cresson.

Treasurer,

J. Sergeant Price.

Councilors to serve for three years,

Alfred L. Elwyn, Benj. H. Coates, Benj. V. Marsh,
Geo. H. Horn.

Mr. Lesley was nominated Librarian.

Pending nomination No. 791 and new nomination No. 792 were read.

Mr. Price reported for the Committee on the Eulogium of the Hon. Horace Binney, that it was acceptably delivered on the evening appointed, and that the MSS. was already in the printer's hands.

On motion, the subject of the present condition of the space alongside of the Hall was referred to the Hall Committee for speedy action.

And the meeting was adjourned.

On the Progress of the Museum and Palæontological Work of the Second Geological Survey of Pennsylvania, for the year 1875.

By Charles E. Hall.

(*Read before the American Philosophical Society, January* 15, 1876.)

The principal collections received from the Assistants and their parties have generally been to demonstrate the sections made by them in their particular districts.

The following collections of fossils have been made :

A series of specimens representing a section from Bellefonte, Centre County, to the Allegheny Mountain, including specimens from the Limestone of II up to the Coal Measures. Number of specimens 165. A collection of bituminous and cannel coals, also cokes. By Mr. F. Platt.

A series of specimens representing the horizons of the Mountain and Oil sands with their included measures and fossils from Venango, Warren, Foster and Crawford Counties. By Mr. J. F. Carll.

Specimens from Mifflin County, representing the Logan and Lewistown Sections;—from Graham's, Snyder's and McKees' fossil-ore openings;—McVeytown Section, including Ross's, McCoy's and Dull and Brady's Ore Banks (Marcellus hematite);—Mt. Union Section. Number of specimens 747. By J. H. Dewees.

Specimens from the South Mountain district, including some fossils. By Prof. Fredk. Prime, Jr.

Specimens of sandstone with Scolithus linearis, from Franklin County. By Prof. P. Frazer, Jr.

Collection of Coal Plants from Washington and Green Counties. By Prof. Stevenson and J. C. White.

Collection of Fossils from the Chemung and Catskill, with section through a portion of the Chemung, Tioga County. By A. Sherwood.

Collection of Fossils from the Hamilton Group at Marshall's Falls, Monroe County. By H. Martyn Chance.

Specimens representing a section from the Limestone of II at Orbisonia to the Coal Measures of Broadtop Mountain, Huntingdon County. Number of specimens 350. By C. E. Billin and C. A. Ashburner.

Besides these there have been special palæontological collections made at the following localities during the past summer :

From the Carboniferous in Westmoreland County, and in Washington and Greene Counties.

From the Catskill, in Tioga County.

From the Chemung group, from eight localities in Tioga County.

From the Hamilton group at Marshall's Falls and vicinity, in Monroe

County; at Orbisonia and vicinity in Huntingdon County; and at Bell's Mills in Blair County.

From the Oriskany Sandstone at Orbisonia and vicinity.

From the Lower Helderberg, at Orbisonia and vicinity, and at Mansing's Quarry, Carbon County.

From the Clinton Group, at McKee's ore bank, Mifflin County; at Matilda Furnace, Mifflin County; at Orbisonia, in Huntingdon County; at Bell's Mills, in Blair County; and at Hollidaysburg, in Blair County.

From the Oneida Conglomerate at Port Clinton, Schuylkill County.

From the Utica Slate and Hudson River group; at Bellefonte, Centre County; near Henrietta, Bedford County; at Henrietta, Blair County.

From the Trenton Limestone; in the Kischicoquillas Valley, Mifflin County; at Bellefonte, in Centre County.

From the horizon below the Trenton; at Reedsville, Kischicoquillas Valley, Mifflin County; from near Bellefonte, Centre County; and from near Martinsburg, Blair County.

The following list of genera and species shows the result of the season's work. I have also included those mentioned by Prof. H. D. Rogers in the First Survey, many of which I have been able to recognize in our limited collection. All the species, except those of the Chemung have been collected during the past summer.

UPPER CHEMUNG (*and Waverly*).

Actinocrinus,
Aristozoa,
Bellerophon,
Carina hamiltonæ,
Cyrtina hamiltonensis,
Cystids,
Discina newberryi,
Dithyrocaris,
Euripterus,
Fenestella,
Lepidechinus,
Lingula delia,
Modiomorpha alta.
Orthoceras,
Platyceras,
"
Productella boydii
" costatula,
" striatula,
Rhynconella contracta,
Spirifer alta,
" disjuncta,
Streptorynchus chemungensis.

These specimens are from Warren and Venango Counties, from J F. Carll, and F. A. Randall.

CHEMUNG. (*Vergent, VIII.*)

Athyris angelica,
" polita,
Atrypa spinosa,
Discina newberryi,
Gramnysia,
Productella lachrymosa var. stigmata,
" striatula,
Rhynconella orbicularis,
Spirifer disjuncta,*
Streptorynchus chemungensis,*

* Those marked * are mentioned by Rogers.

Modiomorpha
Orthis impressa,
Productella boydii,
Strophodonta cayuta,
" concava,
" perplana,

The above are from Tioga County.

HAMILTON GROUP. (*Cadent, VIII.*)

Aviculopecten princeps,
Athyris spiriferoides,*
Atrypa reticularis,
Ambocœlia umbonata,
Bellerophon,
Chonetes mucronatus,
" coronata,
Cryptonella planirostra,
Cimitaria recurva,
Discina grandis,
" newberryi,
Dalmania,
Fenestella,*
Gramnysia,
Heliophyllum halli,
Modiolopsis modiomorpha,
Lingula ligea,
Phacops bufo,*
Rensselæria? johanni,
Rynconella dotis,
Spirifer fimbricata,
" granulifera,*
" medialis,*
" mucronatus,*
" sculptilis,
Strophodonta concava,
" rhomboidalis,
Trepidoleptus carinatus,
Tentaculites.

All the above are from Marshall's Falls, Monroe County, Pa.

Rogers, p. 827, gives the following, also:

Atrypa aspera,
Spirifer congesta,
Strophodonta perplana,
Strophodonta demissa,
Trematospira hirsuta,

ORISKANY SANDSTONE. (*Meridian, VIII.*)

Cyrtoceras expansus,
Dalmania micrurus,
Etonia peculiaris,
Megambonia lamellosa,
Orthis hipparionyx,*
Platyceras ventricosa,
Pterinea texilis,
Rensselæria marylandica,
" ovalis,
" ovoides,*
Spirifer arenosus,*
" arrectus.

All these are from the vicinity of Orbisonia.

LOWER HELDERBERG. (*Pre-Meridian, VI.*)

Acevalaria,
Alveolites minima,
Alveolites,
Artylospongia inornata,
Merista lævis,*
Orthis oblata,
Pentamerus galeatus,*
Rhynconella formosa,

* Those marked * are mentioned by Rogers.

Artylospongia,	Stromatopora,
Atrypa reticularis,	"
Aulopora,	Trematospira formosa,
Conophyllum,	Zaphrentis.
Merista arcuata,	

All the above are from Aughwick Valley, near Orbisonia.

Rogers, p. 825, gives the following, also:

Etonia peculiaris,	Spirifer macropleurus,
Platyostoma,	" sulcatus,
Rhynconella nobilis,	Strophodonta punctulifera.

NIAGARA, WATERLIME, AND ONONDAGA, OR SALINA. (*Scalent, VI.*)

Rogers, p 824, gives the following:

Beyrichia pennsylvanica,	Tentaculites ornatus.
Leperditia alta,	

CLINTON GROUP. (*Surgent, V.*)

Atrypa reticularis,*	Ferguson and Aughwick valley.
Beyrichia lata,	" " " "
Buthotrepis gracilis,*	" " " "
Dalmania limulurus,	" " " "
Homalonotus delphinocephalus,	" " " "
Illænus barrienis,	Ferguson valley, Mifflin county.
Merista intermedia,*	Bell's Mills, Blair county.
Modiolopsis subcarinatus,	Ferguson valley.
Orbicula,	Bell's Mills.
Orthis elegantula,*	Ferguson and Aughwick valley.
Orthonota curta,	" valley.
Platyostoma niagarensis,	" and Aughwick valley.
Pterinea emacerata,	" " " "
Pterinea rhomboidea,	" valley
Rhynconella neglecta,	" and Aughwick valley
" robusta,	" valley.
Spirifer radiatus,	Bell's Mills.
Strophomena rhomboidalis,*	Ferguson and Aughwick valley.
" subplana,*	" valley.
Strophodonta prisca,	" "

ONEIDA CONGLOMERATE AND MEDINA SANDSTONE. (*Levant, IV.*)

Arthrophycus harlani.*	Mifflin and Schuylkill Counties.

Rogers, p. 822, gives the following, also:

Bucania trilobatus,	Lingula cuneata.

* Those marked * are mentioned by Rogers.

UTICA SLATE AND HUDSON RIVER. (*Matinal, III.*)

Chætetes lycoperdon,	Canoe valley.
Glyptocrinus decadactylus,*	" "
Graptolithus,	" "
Strophomena,	" "
Triarthrus beckii,*	Nittany valley.

Rogers, p. 818, gives the following, also:

Agnostus lobatus,	Lingula quadrata,
Ambonychia bellistriata,	Modiolopsis modiolaris,
" radiata,	Murchisonia gracilis,
Avicula insueta,	Orbicula,
Bellerophon bilobatus,	Ormoceras crebriceptum,
Conularia trentonensis,	Orthis lynx,
Cyrtolites ornatus,	Orthoceras vertebrale,
Endoceras proteiforme,	Pleurotomaria bilix,
Graptolithus pristis,	" subconica,
Heterocrinus,	Rhynconella increbescens,
Lingula curta,	Stictopora acuta.

TRENTON LIMESTONE. (*Matinal, II.*)

Calymene senaria,	Nittany valley.
Chætetes lycoperdon,*	" and Kischicoquillas valley, and Northampton county.
Crytoceras trentonensis,	Nittany valley.
Dalmania gigas,*	" "
Eschapora recta,	Kischicoquillas valley.
Leptæna sericea,*	" and Nittany valley.
Lingula riciniformis,	Nittany valley.
Orthis testudinaria,*	Nittany and Kischicoquillas valley.
" tricinaria,	" valley.
" pectinella,*	Northampton county.
Stictopora elegantula,	Kischicoquillas valley.
Strophomena alternata,*	Nittany and Kischicoquillas valley.
" deltoidea,	Nittany valley.
Trinucleus concentricus,*	" and Kischicoquillas valley.

BLACK RIVER LIMESTONE. (*Matinal, II.*)

Chætetes lycoperdon,	Canoe valley.
Gonioceras anceps,	" "
Murchisonia angustata,	Kischicoquillas valley.

* Those marked * are mentioned by Rogers.

Orthoceras multicameratum,*.....Canoe valley.
Pleurotomoria umbilicata,*..... " "

Rogers, (p. 817) mentions the following, not as yet observed :

Euomphalus ungulatus,	Ophileta levata,
Maclurea matutina,	Pleurotomaria nucleolata,
" magna,	Pleurotomaria turgida,
Murchisonia bicincta,	Retapora staminea,
Leperditia ovata,	" striata,
Orthoceras tenuifillum,	Rhynconella plicifera.

CHAZY LIMESTONE. (*Matinal, II.*)

Asaphus canalis,*.....Kischicoquillas valley.
" marginalis,..... " "
Orthis costalis,..... " "
Orthoceras, ... " "
Strophemena incrassata,*..... " "

LOWER LIMESTONES. CALCIFEROUS. (*Auroral, II.*)

Asaphus,.....Nittany valley.
Euomphalus,.....Canoe valley.
Illænus, ...Nittany valley.

POTSDAM SANDSTONE. (*Primal, I.*)

Scolithus linearis,.....Lehigh and Franklin counties.

In the above list no mention is made of the organic animal remains of the Coal Measures, no collections in these having been as yet systematically made. Those observed by Prof. J. J. Stevenson in Washington and Greene Counties will be recorded in his forthcoming report of 1875.

An important collection recently sent in by Mr. Carll has not yet been sufficiently studied to be included in the present notice.

* Those marked * are mentioned by Rogers.

Contributions to the Physical Geography of the United States, by Charles Allen, Assistant in charge of the Collection and Collation of Railroad and other Levels for the Second Geological Survey of Pennsylvania.

By J. P. Lesley.

(*Read before the American Philosophical Society, January* 15, 1876.)

In presenting to the attention of the members Mr. Allen's list of Pennsylvania levels, I have only to say that the progress of physical geography in the United States has been so rapid, of late years, as to attract the attention of the Scientific world at home and abroad, and that its connection with the progress of geological science is so intimate, that working geologists hail with lively pleasure the publication of all hypsometrical records of a genuine kind, whether old or new. For want of government bureaus of statistics the greater part of such records have been irrecoverably lost. Of the tentative work of our railway, canal, slackwater and turnpike companies, done between 1830 and 1860, scarcely a trace remains; although, if its records could be recovered and printed, they would furnish copy for hundreds of volumes. Since 1860 the destruction has not been so complete, but has been nevertheless very great. There are recent important surveys of which no records can be found, even in the offices of the companies for whom they were made.

This important subject has received well-deserved attention at the hands of the chiefs of the United States Exploring Expeditions, who are mapping the interior of the Continent. But some efficient organization is required for the preservation and publication of levels in the States lying between the Atlantic and the Mississippi.

The State Geologists of Ohio and North Carolina, also, have published valuable hypsometric tables.

A beginning has now been made in Pennsylvania; and the following pages contain the records of the height above some assumed datum, reduced to tide level, of all stations on railways in the State, and in its immediate vicinity.

These records have mostly been obtained by personal examination of the profiles preserved at the offices; and in some cases, by letter, from superintendents and engineers. The greatest interest in the Collection has been manifested by members of the profession of Civil Engineering to whom application has been made; and in some instances, where records were wanting, new levelings have been ordered and the results transmitted.

Short headings are prefixed to the records, stating place, date and authority; and foot notes appended to them, stating difficulties of adjustment, incongruities, or doubts.

That a work of this nature should have the advantage of first publication in the transactions of the oldest Scientific Society of America, whose first President was Benjamin Franklin, and whose hall stands side by side with the ancient Capitol of the United States, is my reason for asking that this first systematic attempt on a large scale to render permanent and useful to all engineers and surveyors the scattered and perishable records of heights above sea-level of several thousand points in our valleys and on our mountains should be accepted by the Society.

It must be understood, however, that these lists require thorough re-examination and correction before they can be adopted as constants of science for the future. There are considerable difficulties yet to be encountered by such as undertake to harmonise the data of our railway surveys. Indeed, considering the imperfect way in which such surveys are necessarily made,—the accumulation of errors of instrumentation and personal equation along every long spirit-level line,—the uncertainty even of the tide-level datum at every head of tide,—the frequent lack of notes stating whether railway levels cross each other on grade, or not,—and the not uncommon fact that, after location-surveys have

been made, the road-beds have been tempered up, or down, to suit convenience, and no record of the fact been kept, except in the memory of some division engineer no longer in the employ of the Company,—it is surprising that the errors of terminal or crossing adjustment are so few and small. But to render the record perfect all such errors, however few and small, must be eliminated; and this can only be accomplished by a zealous interest taken in the subject by resident engineers; who are therefore earnestly requested to co-operate to this end.

Geologists are dependent for the goodness of their field-work on accurate base-line levels. And it is to be hoped that a complete exhibition of the surface contour of Pennsylvania will sooner or later be obtained from a collation of the thousands of transit-lines and barometer-lines now in progress in all the districts occupied by the Assistant Geologists of the Survey. All their lines of levels are, however, based on the railroad records, and the publication of these in a corrected form is a necessary preliminary step.

If movements are still taking place in the crust of the earth,—and the frequent occurrence of slight earthquake shocks, in all the States of the Union, seems to speak in favor of the supposition,—physical philosophers are peculiarly interested in an early establishment of a universal hypsometrical record. From this point of view, also, it would seem especially germain to the origin and history of the American Philosophical Society to initiate such a record.

The net-work of Surveys which cover Pennsylvania may be divided into nine systems:

1. The Pennsylvania Central east and west system, from Trenton through Philadelphia, Harrisburg, Altoona, Pittsburgh, to Steubenville, and Youngstown, in Ohio; with numerous longer or shorter side branches.

2. The Reading Railroad northwest and southeast system, with many short branches in the Schuylkill Anthracite Field, and through the country in front of it between the Delaware and Susquehanna Rivers. It has been extended also to the

waters of the Upper Susquehanna, and will penetrate into New York State.

3. The North Pennsylvania north and south system, with numerous branches in the Lehigh and Wilkesbarre Anthracite Fields, in connection with the two Lehigh Valley Railroads, extending into the State of New York.

4. The Northern Central north and south system, extending from Baltimore, in Maryland, to Elmira, in New York, with several short branches.

5. The Philadelphia and Erie northwest system, with important branches crossing to the Alleghany River, and into the State of New York.

6. The Alleghany River north and south system, from Pittsburgh to the Oil Region, and Buffalo in New York.

7. The Baltimore and Ohio system, with its Connellsville branch to Pittsburgh, and its short coal and coke branch.

8. The Beaver River system, north and south, along the western margin of the State.

9. The Philadelphia, Wilmington and Baltimore southwest system.

The following tables are arranged in the above order, and will explain themselves:

I. The Pennsylvania R. R. System.

I. Pennsylvania Railroad.

Note.—The elevations at the various stations, on the Pennsylvania Railroad, were copied from the Engineers' notes, by permission of Mr. W. H. Wilson, its Consulting Engineer.

The datum, or base of levels, is ordinary high-water in Schuylkill River. This datum, according to Mr. James T. Gardener's determination, is 6.913 feet* above mean surface of the Atlantic Ocean. *These 7 feet are added in the second column.* Decimal parts of a foot do not occur in these lists. When below .5 they have been omitted; when more than .5 a whole number has been substituted.

* Permanent U. S. Coast Survey granite bench at Gloucester Ferry, N. J., opposite Philadelphia, is 8.10 above Mean Tide Raritan Bay, or Mean Ocean level. Mean Tide Delaware River — 8.10 — 4.751 — 3.349. Philadelphia City Surveyor's datum: 8.10 — 0.632 — 8.732. Pennsylvania R. R. Engineer's datum: 8.10 — 1.819 High tide, 6.913.

Pennsylvania R. R. Main Line.

STATIONS.	High Tide, Philad'a.	Above mean level Atlantic Ocean.	
Philadelphia, Market Street	25	32	
West Philadelphia	27	34	
Powelton Avenue	38	45	
Fairmount Bridge	44	51	
Mantua	94	101	
Belmont Avenue	103	110	
Hestonville	136	143	
City Avenue	214	221	
Merion	240	247	
Elm	278	285	
Wynnewood	308	315	
Ardmore	352	359	
Bryn Mawr	409	416	
Rosemont	388	395	
Villa Nova	423	430	
Union	423	430	
Radnor	402	409	
Edgewood Avenue	394	401	
Wayne	398	405	
Reeseville	488	495	
Paoli	527	534	
Green Tree	536	543	
Malvern	539	546	
Fraser	483	490	
Glenlock	446	453	
Ship Bridge *	404	411	
Walkertown	381	388	
E. B. & W. R. R. See Tab. II.	248	255	
Downingtown	259	266	
Gallaghersville	291	298	
Thorndale	306	313	
Cain	352	359	
Coatesville (W. & R. R. R.) Tab. LVI.	373	380	
Midway	387	394	
Pomeroy. P. & D. R. R. Tab. III.	476	483	
Chandlers	482	489	
Parkesburg	530	537	
Summit †	551	558	
Penningtonville	493	500	
Christiana	484	491	
Summit ‡	566	573	
Gap	552	559	
Kinzers	461	468	
Spindlers	397	404	
Leamen Place	375	382	
Gordonville	378	385	
Fairview	378	385	
Bird in Hand	352	359	

* Intersection of Waynesburg Branch.
† West of Parkesburg.
‡ East of Gap Station.

STATIONS.		High Tide, Philad'a.	Mean Tide Atlantic Ocean.	
Lancaster ‡		352	359	
Dillerville Junction ‖	Columbia Line.	352	359	
Rohrerstown §		345	352	
Mountville		397	404	
Columbia		244	251	
Chiquies		248	255	
Marietta		253	260	
Shocks Mill		262	269	
Bainbridge		264	271	
Collins		278	285	
Middletown Junction (*a*).		307	314	
Landisv'e R.&C.R.R. (*b*). Tab. LVII		398	405	
Salunga		396	403	
Chiquies Bridge		344	351	
Mount Joy (*c*)		359	366	
Springville		383	390	
Reams		432	439	
Tunnel		472	479	
Elizabethtown		450	457	
Conewago		422	429	
Middletown		307	314	
Highspire		293	300	
Harrisburg *		313	320	
Susquehanna		335	342	
Susquehanna Bridge		343	350	
Marysville		343	350	
N. C. R. R. Crossing † Tab.		342	349	
Duncannon		349	356	
Aqueduct		370	377	
Bailys		380	387	
Newport		388	395	
Millerstown		401	408	
Thompsontown		412	419	
Tuscarora ¶		422	429	
Mexico		426	433	
Perryville		434	441	
Mifflin		434	441	
Black Log		455	462	
Bixlers		475	482	
Lewistown		491	498	
M. & C. C. R. R. Crossing ‖ Tab. V.		492	499	
Granville		491	498	

‡ Bench Mark on Stone Wall, Lancaster Locomotive Works, 339.

‖ Junction of Columbia Branch, at Dillerville.

§ On Columbia Branch.

(*a*) Junction of Columbia Branch, at Middletown.

(*b*) Reading and Columbia R. R. Crossing, at Landisville.

(*c*) East side of R. R. Hotel.

* West line of depot 313.91. Curb stone at lamp post U. S. Hotel 313.54. West line of Lebanon Valley Depot 315.5. West line of State street 319.2.

† Northern Central R. R. Crossing.

¶ Bench Mark on top of Stone foundation west corner of Water Station 424.44.

‖ Junction at Mifflin and Centre County R. R.

STATIONS.	High Tide, Philad'a.	Mean Tide Atlantic Ocean.	
Anderson's	493	500	
Anderson's. Water Station	492	499	
McVeytown	515	522	
Manayunk	512	519	
Vineyard	541	548	
Newton Hamilton	592	599	
Mount Union. § E. B. T. Tab. VII.	590	597	
Jackstown	588	595	
Mapleton	586	593	
Mill Creek	597	604	
Huntingdon.* H.& B.T.Tab. VIII.	615	622	
Warrior Ridge	670	677	
Petersburg	671	678	
Sherman's Bridge †	692	699	
Barre Forge	717	724	
Tunnel ‡	754	761	
Spruce Creek	770	777	
Union Furnace	792	799	
Birmingham	859	866	
Tyrone Water Station	889	896	
Tyrone R.R. Tables XIII. XIV. XV.	900	907	
Tipton	983	990	
Fostoria	1022	1029	
Bells Mills R. R. Table XVIII.	1053	1060	
Elizabeth Furnace	1072	1079	
Blair Furnace	1107	1114	
Altoona ‖ R.R. Tables XIX.–XXIII	1171	1178	
Kittanning	1587	1594	
Murdocks	1619	1626	
Alligrippus	1913	1920	
Bennington Furnace	2031	2038	
Tunnel ¶	2119	2126	
Gallitzin	2154	2161	
Cresson (*a*) E.&C.R.R. Tab. XXIV.	2010	2017	
Lillys	1880	1887	
Portage	1668	1675	
Wilmore	1550	1557	
Summit (*b*)	1562	1569	
Summerhill	1550	1557	
South Fork	1477	1485	
Viaduct (*c*)	1449	1456	

§ Junction of East Broad Top R. R. (narrow guage).

* West line of ticket office, crossing south track west to Huntingdon & Broad Top R. 613.9.

† Bench Mark on west end of bridge.

‡ West end of Spruce Creek Tunnel.

‖ West line of ticket office 1171. B. M. (Bench Mark) south-west corner, top step front door of ticket office 1174.

¶ B. M. at east end of Tunnel, on rough part of first course of stone above foundation.

(*a*) Switch to Ebensburgh and Cresson R. R. 2021.

(*b*) Pringles point.

(*c*) Bench Mark on N. W. corner west end of coping.

STATIONS.	High Tide, Philad'a.	Mean Tide Atlantic Ocean.	
Mineral Point	1407	1414	
Conemaugh	1218	1225	
Johnstown	1177	1184	
Sandy Hollow	1136	1143	
Conemaugh Furnace	1128	1135	
Nineveh	1134	1141	
New Florence	1069	1076	
Houstons	1049	1056	
Lockport	1047	1054	
Bolivar	1026	1033	
Blairsville Junction * Tab. XXV.	1106	1113	
Hillside	1122	1129	
Millwood	1148	1155	
Derry	1165	1172	
Lindorff's Summit	1178	1185	
St. Clair { Lig. R.R. Tab. XXIX. }	1085	1092	
Latrobe { Lig. R.R. Tab. XXIX. }	999	1006	
Beatty's	1066	1073	
Kearney's †	1041	1048	
Shanghai	1166	1173	
Carr's Tunnel ‡	1201	1208	
George's	1199	1206	
Greensburg ‖ S. W. P. RR. Tab. XXX.	1084	1091	
McGrau's Tunnel §	1156	1163	
Radebaughs	1143	1150	
Grapeville	1052	1059	
Penn	967	974	
Manor	935	942	
Shafton	893	900	
Irwin's. Y. R. R. Table XXXI.	877	884	
Larimer's	859	866	
Carpenter's	847	854	
Stewart's	784	791	
Wall's	744	751	
Springhill	742	749	
Turtle Creek	743	750	
Oak Hill	743	750	
Brinton's	750	757	
Braddock's	821	828	
Copeland	846	853	
Hawkins'	876	883	
Swiss Vale	915	922	
Edgewood	916	923	
Wilkinsburg	916	923	
Brushton	915	922	

* Intersection of Blairsville and Indiana Branch of Pa. R. R. with main line.

† Rogers' Summit 1201.8.

‡ East face of Tunnel.

‖ B. M. east face of Greensburg Tunnel on top of rough part of second course from bottom 'R' 1079.52.

§ West face of tunnel.

STATIONS.	High Tide, Philad'a.	Mean Tide Atlantic Ocean.	
Homewood	916	923	
Torrens	913	920	
East Liberty	911	918	
Roups'	875	882	
Shadyside	859	866	
Millvale	826	833	
Lawrenceville	773	780	
Pittsburgh *	738	745	

II. East Brandywine Railroad.

NOTE.—The levels on the East Brandywine and Waynesburg R. R. were furnished by Mr. W. H. Wilson, Consulting Engineer of the Pennsylvania R.R. The datum, or base of levels is ordinary high water in Schuylkill River, Philadelphia. Therefore 7 *feet are added in the second column to reduce to mean tide in the Atlantic Ocean.*

STATIONS.	High Tide, Philad'a.	Ocean Level.	
Downingtown Terminus. † Table I.	249	256	
Shelmeirs	239	246	
Dowlin's Forge	271	278	
Dorlan's	273	280	
Reed's Road	302	309	
Brooklyn	329	336	
Cornog's	354	361	
Springton	398	405	
Moorestown	436	443	
Barnestown	479	486	
Lewis Mills	535	542	
Cupola	556	563	
Forrest	564	571	
Dampman's	624	631	
W. & R. R. R. ‡ Table LVI.	666?	673?	
Buchanan's	665	672	
Lancaster Pike	689	696	
Waynesburg	721?	728?	
End of Track	734	741	

* West face of Union Passenger Depot, east side of Wayne Station 734.5. East side of Irwin street 729.7. East side of Duquesne street depot 725.4. Bench Mark at foot of lamp post south side of Liberty street, intersection with Water street 721.27.

Bench Mark on south side of base ring, of fire plug, north side of Penn street, intersection with Water street, 719.

† Junction with north track of the Pa. R. R. near Downingtown.

‡ Crossing Wilmington and Reading R. R.

III. Pennsylvania and Delaware R. R.

NOTE.—The elevations on the Pennsylvania and Delaware Railroad were obtained in the office of Mr. George W. Leuffer, C. E., of Philadelphia.

At Pomeroy Station, 43 miles of Philadelphia, this road joins the Pennsylvania R. R. Mr. Leuffer makes this point 472.9; Mr. Wilson 476.039. To Mr. Leuffer's levels in the first column are therefore added 3 feet to accord with the P. R. R. list, and an additional 7 feet to reduce to mean Atlantic tide level.

STATIONS.	High Tide, Philad'a.	Ocean Level.	
Pomorey Junction * Table I.	472.9	483	
Doe Run	364	374	
Pusey's Summit	460.	470	
Pennock's Summit	453	463	
Avondale ** Table	271.6	281.6	
Newark †	108	118	
Delaware R. R. Crossing ‡	76.2	86.2	
Delaware City	6.	16	

IV. York Branch P. R. R.

The levels on the York Branch of the Pennsylvania R. R. were copied from the profile in the office of the P. R. R. at Philadelphia.

In accordance with instructions of Mr. W. H. Wilson, 3′ was added to each elevation, as shown on the profile, in order to agree with the level of Columbia according to Pa. R. R.; and also 7 feet to reduce to mean Ocean level.

STATIONS.	High Tide, Philad'a.	Ocean Level.	
Columbia § Table I.	241.3	251.3	
Wrightsville	247.5	257.5	
Creitz Creek ‖	263.	273.	
Hellam	336	346	
Heistand's	327.2	337.2	
York (N. Central R. R.) Tab.	371.7	381.7	

* Junction with Pennsylvania R. R. at Pomeroy Station, 43 (42.2?) miles west of Philadelphia.

** Crossing the Philadelphia and Baltimore Central R. R.

† Crossing of the Delaware Railway Line.

‡ Crossing of the Philadelphia, Wilmington and Baltimore R. R.

§ Junction with the Columbia Branch of the Pa. R. R.

‖ Bench mark on east end of coping girder of bridge No. 3, over road and Creitz Creek.

V. Mifflin and Centre Co. R. R.

The levels of the Mifflin and Centre Co. Railroad were copied from a profile in the office of the Pennsylvania R. R. Co., at Philadelphia, furnished by Mr. W. H. Wilson, Consulting Engineer, Pennsylvania R. R.

The datum is that of the Pennsylvania R. R., 7 *feet added*, to reduce to mean Atlantic level, in the second column.

STATIONS.	Above Tide.	Ocean Level.	
Lewistown Junction*.....	492	499	
Logan.....	527	534	
Yeagertown.....	561	568	
Mann's.....	673	680	
Reedsville.....	695	702	
Honey Creek.....	807	814	
Nagney.....	849	856	
Milroy†.....	987	994	

VI. Sunbury and Lewistown R. R.

NOTE.—No records of this road could be obtained.

VII. East Broad Top Narrow Gauge R. R.

The levels on the East Broad Top R. R. (3 foot gauge), were copied from a profile in the office of the Company, at Orbisonia, by permission of Mr. A. W. Sims, Superintendent.

The datum of the profile is an assumed elevation, and has been reduced to tide level by reference to the Pennsylvania R. R. grade at Mount Union, 500′, with 7′ added to reduce to mean Atlantic Ocean level.

STATIONS.	Assumed Datum.	Ocean Level.	
Mount Union Junction ‡.....	810.65	597	
Morrison's Summit.....	828	615	
Aughwick Creek.....	773.60	560	
Shirleysburg.....	784.94	572	
Douglas Summit.....	811.24	598	
McMullen's Summit.....	882.74	669	
Orbisonia.....	837 62	624	
Jordan's Summit.....	922.22	709	
Scottsville.....	929.85	717	
Saltillo.....	994.70	781	
Moreland's Summit.....	1326.90	1114	
Sidling Hill.....	1445.47	1232	
Cole's Station.....	1572.06	1359	
Cook's Mill.....	1741.28	1528	
Cook's Station.....	1754.24	1541	
Coal Openings.....	1978.10	1765	
Robertsdale.....	1998.70	1785	
End of Road §.....	2030.02	1817	

* With the Pennsylvania R. R. near the Lewistown Station. Table I.

† Terminus in the Kishicoquillis Valley. This survey has been extended through the Seven Mountains to Bellefonte.

‡ East Broad Top R. R. connects with Pennsylvania R. R. at Mount Union.

§ On the plateau of the Broad Top Mountain in Huntingdon County.

VIII. Huntingdon and Broad Top R. R.

The levels on the Huntingdon and Broad Top R. R. and its Branches, were furnished by Mr. John Fulton, General Mining Engineer of the Cambria Iron Works at Johnstown, Pa.

The datum is 0 at grade on the Pennsylvania R. R. at Huntingdon. To this 614′ are added, + 7′, to reduce all to mean Atlantic Ocean level.

This road has three coal branches up the three streams which drain the Broad Top Coal Region. It originally stopped at Everett; but has been continued to Bedford and Bridgeport under the name of the Bedford and Bridgeport Railroad. Table IX.

The elevations on the Bedford and Bridgeport R. R. were furnished by Mr. S. M. Prevost, Superintendent of the Bedford Division of the Pennsylvania R. R.

The datum 0 of this road was at grade of the Pennsylvania R. R. at Huntingdon; which Mr Prevost called 610; while Mr. Wilson calls it 614. The difference of 4 feet has therefore, in the 2d column, been added to Mr. Prevost's figures, to make them agree with Mr. Wilson's figures, along the main line. The regular 7 feet addition has also been made in the second column to reduce to mean Atlantic Ocean level.

STATIONS.	Above Huntingdon.	Ocean Level.	
Huntingdon	000	621	
McConnellstown	56.2	677	
Pleasant Grove	127.2	748	
Marklesburg	167.6	789	
Coffee Run	250.6	872	
Rough and Ready	267.6	889	
Cove	300	921	
Fisher's Summit	253	874	
New Bridge	210.3	831	
Saxton (new depot)	228	849	
Riddlesburg	243.6	865	
Hopewell	277.3	898	
Piper's Run	326.3	947	
Brallier's Summit	487.3	1108	
Tatesville	475.3	1096	
Bloody Run Summit	613.3	1234	
Everett	497 3	1118	

IX. Continued as the Bedford and Bridgeport R. R.

Mount Dallas (above tide)	1046	1053	
Cove Creek	1026	1033	
Lutzville	1038	1045	
Bedford	1055	1062	
Wolfsburg Summit	1111	1118	
Napier	1101	1108	
Mann's Choice	1129	1136	
Buffalo Summit	1349	1356	
Fossilville	1084	1091	
Bridgeport (*a*)	923	930	
Maryland State Line (*b*)	837	840	

(*a*) Not the Bridgeport of Clearfield County in Table XIV.

(*b*) Continued as Baltimore, Connellsville & Pittsburgh R. R. Branch of the Baltimore and Ohio R. R.

X. Shoup's Run Branch of H. & B. T. R. R.

Saxton (as above)	228	849
Coalmont	488.8	1110
Crawford	620.9	1242
Old M. P	662 7	1284
No. 3. Mine	784.5	1405
Barnet Mine	767	1388
Dudley Station	803.6	1425
Blair's Mine	815.2	1436
Moredale	1058.7	1680
Water Station	1088	1709
End of Track	1240.2	1861

XI. Six Mile Run Branch of H. & B. T. R. R.

Riddlesburg (as above)	243.6	865
" Coal Mine	340.9	962
Coaldale	505.2	1126
End of 3d Mile	573	1194
End of 4th Mile	753	1374
End of Track	795	1416

XII. Sandy Run Branch of H. & B. T. R. R.

Hopewell (as above)	277.3	898
End of Track	404	1025

XIII. Lewisburg, Centre and Spruce Creek R. R.

NOTE.—The levels on the Lewisburg Centre and Spruce Creek R. R. were furnished by Mr. George W. Leuffer, Chief Engineer. Mr. Leuffer says, "I will remark that many of the Stations have, as yet, not been located. The tide levels are based upon a level furnished by A. B. Starr, Esq., Engineer of P. & E. R. R., of a point in abutment of Chilesquaque Bridge (of P. & E. R. R.), and this agrees so closely with the level of tide, as stated in printed table of Pennsylvania R. R. Co., of Tyrone City, that I am inclined to rely upon the levels I now enclose."

The first column, then, gives the figures of Mr. Leuffer.

The second column has 7 feet added to Mr. Leuffer's figures, on the supposition that his datum is Pennsylvania R. R. datum of high water at the Schuylkill Bridge.

The third column has 8 feet added (in addition, = 15 feet in all) to agree with the final mean Atlantic Ocean level assigned to Tyrone, in the Pennsylvania R. R. list, No. I.

STATIONS.	Above Tide.*	Ocean Level.†	Ocean Level.‡	
P. & E. R.R. Junction(*a*)	447	454	462	
Lewisburg	451	458	466	
Biehl	503	510	518	
Vicksburg	514	521	529	
Mifflinburg	550	557	565	
Millmont	570	577	585	
Laurelton	592	599	607	
Tunnel (*b*)	944	951	959	
Fowler's	976	983	991	
Beaver Dam Tunnel	999	1006	1014	
Caburn (*c*)	1011	1018	1026	
Buchannon (*d*)	1044	1051	1059	
Duncan	1063	1070	1078	
Centre Hall	1257	1264	1272	
Summit (*e*)	1275	1282	1290	
Lemont (*f*)	987	994	1002	
Kelly (*g*)	1096	1103	1111	
Pinegrove	1221	1228	1236	
Shugarts	1116	1123	1131	
Lyon (Penna. Furnace).	1059	1066	1074	
Guyer (*h*)	1129	1136	1144	
Lowrie (*i*)	1094	1101	1109	
Miller (*j*)	1055	1062	1070	
Tyrone (*k*) (I)	892	899	907	

XIV. Tyrone and Clearfield R. R.

The elevations on the Tyrone and Clearfield R. R. were copied from a profile in the office of the Pennsylvania R. R. Co. in Philadelphia. The datum is a point 60′ below Tyrone, or as it appears on the profile elevation at Tyrone +840′. Mr. W. H. Wilson is authority for adding 60′ to each elevation as shown on the profile.

In the second column seven feet are added to reduce to mean Atlantic Ocean Level.

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* High tide, Schuylkill River, at Philadelphia?

† Calculated from the Lewisburg end.

‡ Adjusted to the Pennsylvania R. R. record at the Tyrone end.

(*a*) Junction with Philadelphia and Erie R. R.

(*b*) Through Paddy's Mountain.

(*c*) Forks of Penn's Creek.

(*d*) Mouth of Muddy Run.

(*e*) Summit of Penn's Valley, Head of Penn's Creek, and Head of Spring Creek, which enters Bald Eagle Creek after passing Bellefonte.

(*f*) End of Nittany Mountain.

(*g*) State Agricultural College.

(*h*) Half Moon Gap.

(*i*) At Warrior's Mark.

(*j*) Logan's Run.

(*k*) L. C. & Sp. Cr. R. R. here connects with the Pennsylvania R. R.

STATIONS.	Above Tide.	Ocean Level.	
Tyrone (Pennsylvania R. R.)..(I)	900	907	
Bald Eagle R. R. Junction.....	977	984	
Vanscoyoc.....	1410	1417	
Gardners.....	1561	1568	
Mt. Pleasant.....	1767	1774	
Emigh's Summit (*a*).....	2033	2040	
Sandy Ridge.....	1915	1922	
Powelton.....	1791	1798	
Osceola Branch R. R.....	1481	1488	
Dunbar.....	1446	1453	
Moshannon Creek.....	1443	1450	
Steiner's Mill.....	1421	1428	
Philipsburg.....	1415	1422	
Blue Ball.....	1513	1520	
Shimmels.....	1634	1641	
Wallacetown.....	1675	1682	
Turner's Summit.....	1735	1742	
Moravian Run.....	1731	1738	
Ross' Summit.....	1744	1751	
Smael's Summit.....	1709	1716	
Camp Hummel.....	1743	1750	
Bigler.....	1655	1662	
Woodland.....	1465	1472	
Roaring Run.....	1420	1427	
Leonard's Point.....	1299	1306	
Clearfield Creek.....	1133	1140	
Sharon's Run.....	1105	1112	
Liberty Spring.....	1096	1103	
Clearfield.....	1096	1103	
Goodfellow's Bridge.....	1103	1110	
Spackman's Bluff.....	1110	1117	
Susquehanna River.....	1117	1124	
Hog Back.....	1119	1126	
Hartshorn's Run.....	1125	1132	
Curwensville.....	1134	1141	
Anderson's Creek (*b*).....	1144	1151	
Anderson's Creek (*c*).....	1159	1166	
Bridgeport (*d*).....	1183	1190	

XV. Bald Eagle Valley R. R.

The elevations on the Bald Eagle Valley R. R. were copied from a profile in the office of the Pennsylvania R. R. Company, at Philadelphia. The datum is the same as that of the P. R. R.

In the second column seven feet are added to reduce to mean Atlantic Ocean Level.

(*a*) Allegheny Mountain Summit.
(*b*) First Crossing.
(*c*) Second Crossing.
(*d*) Not the Bridgeport of Bedford County in Table IX.

STATIONS.	Above Tide.	Ocean Level.	
Tyrone (as above)	900	907	
Spring Run	888	895	
Dallas Street	921	928	
Sinking Run	923	930	
Little B. E. Creek	940	947	
Bald Eagle	1051	1058	
L. B. E. Bridge	1065	1072	
Summit	1103	1110	
Hannah	1050	1057	
Port Matilda (*a*)	1000	1007	
B. E. Creek Bridge	917	924	
Martha	905	912	
Julian	844	851	
Dick's Run	794	801	
Unionville	775	782	
Snow Shoe R. R.....(XVI)	715	722	
Milesburg.....(XVII)	693	700	
Bald Eagle Canal	664	671	
Holters'	644	651	
Mount Eagle	655	662	
Bald Eagle Plank Road	658	665	
Howard	672	679	
Eagleville	628	635	
Beach Creek	607	614	
Mill Hall	566	573	
Lock Haven Junction (*b*)	548	555	

(*a*) Main Street.
(*b*) Junction with the Philadelphia and Erie R. R.

XVI. Bellefonte and Snow Shoe R. R.

The levels on the Bellefonte and Snow Shoe R. R were furnished by Mr. I. L. Sommerville, Resident Engineer. The datum is that of the Pennsylvania R. R.

In the second column seven feet are added to reduce to mean Atlantic Ocean Level.

STATIONS.	Above Tide.	Ocean Level.	
Bellefonte.....(XVII)	737	744	
Bald Eagle R. R. Junction..(XV)	715	722	
Gum Stump	1013	1020	
Summit (*a*)	1728	1735	
Beach Creek (*b*)	1542	1549	
Beach Creek (*c*)	1592	1599	
Snow Shoe	1565	1572	
Middle Coal bed (*d*)	1599	1606	

(*a*) Allegheny Mountain summit.
(*b*) *Level of water* in Beach Creek.
(*c*) Level of rail over the water.
(*d*) Middle coal bed at the Company's mines at Coal Hill.

XVII. Bellefonte Branch.

The levels on the Bellefonte Branch were copied from a profile in the office of the Pennsylvania R. R. Company, at Philadelphia, and have the datum of the P. R. R. to which are added seven feet to reduce to mean Atlantic Ocean Level, in the second column.

STATIONS.	Above Tide.	Ocean Level.	
Milesburg (*a*).....(XV)	693	700	
B. E. V. Plank Road.....	692	699	
Bellefonte.....(XVI)	737	744	

XVIII. Bell's Gap (N. G.) R. R.

The elevations on the Bell's Gap Narrow Gauge R. R. (3 feet) were furnished by Mr. Jos. Ramsey, Jr., Superintendent.

The datum for the first column is 0 at Pennsylvania R. R. grade at Bell's Mills Station. To which are added 1053′ from Table I for the second column, and 7′ for the third column, to reduce to mean Atlantic Ocean Level.

STATIONS.	Bell's Mills.†	Corrected Tide.	Ocean Level.	
Bell's Mills Junction (I).	0	1053	1060	
Roots'.....	162	1215	1222	
Collier.....	581.6	1635	1642	
Point Lookout.....	854.6	1908	1915	
Lloyd's Junction (*a*)...	1107.4	2160	2167	
Lloyd's Station.....	1119.7	2173	2180	
Summit (*b*).....	1240.5	2294	2301	
Five Foot Coal (*c*).....	——	2116	2123	
Figart's.....	1048	2101	2108	
Vanscoyoc.....	935	1988	1995	
Crees Summit.....	797	1850	1857	
Hollen's (*d*).....	582	1635	1642	
Three Foot Coal.....	——	1667	1674	
Five Foot Coal.....	——	1727	1734	
Van Ormer's (*e*).....	352.3	1405	1412	
Three Foot Coal.....	——	1475	1482	
Fallen Timber.....	362.	1415	1422	

(*a*) Junction with the Bald Eagle Valley R. R.

(*a*) Elevation of 5 foot coal bed at the mouth of gangway.

(*b*) Allegheny Mountain. Bench Mark, Summit of Mountain.

(*c*) Level of the 5 foot coal bed under the Bench Mark.

(*d*) Elevation at this point of the 3′ vein, 1667′; of the 5′ vein, 1727′.

(*e*) Elevation of *Water in Clearfield Creek*. The elevation of the 3′ vein here is 1475.

XIX. Hollidaysburg Branch P. R. R.

The levels on the Hollidaysburg Branch of the Pennsylvania R.R. were copied from a profile in the office of the P. R. R. Company, at Philadelphia.

The datum being mean high tide at the Schuylkill Bridge, seven feet are added in the second column to reduce the mean Atlantic Ocean Level.

STATIONS.	Above Tide.	Ocean Level.	
Altoona (Pennsylvania R. R.)..(I)	1172	1179	
Allegheny.....	1145	1152	
Eldorado	1086	1093	
Canon's	1059	1066	
Duncansville	983	990	
Hollidaysburg .....(XX)	946	953	
End of Line (*a*)	937	944	

(*a*) 3400′ beyond the station marked Hollidaysburg.

XX. Williamsburg Branch P. R. R.

The levels on the Williamsburg Branch, the Morrison's Cove Branch, the Bloomfield Branch, and the Springfield Branch of the Pennsylvania R. R., were copied from profiles in the office of the Pennsylvania R. R. Company, at Philadelphia.

The datum being mean high tide at the Schuylkill Bridge, seven feet are added to reduce to mean Atlantic Ocean Level.

The Williamsburg Branch R. R. has been substituted for the old State Canal, long since vacated, from Frankstown to Williamsburg, and shows the fall of the Juniata River.

STATIONS.	Above Tide.	Ocean Level.	
Graysport (*a*).....	947	954	
Hollidaysburg .....(XIX)	935	942	
Brush Run.....	1026	1033	
Juniata River (*b*)	911	918	
Reese Station	896	903	
Clapper's Run	894	901	
Koofer's Run	886	893	
Juniata River (*c*)	886	893	
Pike Ponds	878	885	
Flowing Spring	874	881	
Springfield R.R. Junc. (*d*) (XXIII)	874	881	
Williamsburg	840	847	

(*a*) Bench Mark on step of ladies' waiting room, Graysport passenger station, 946.60.

(*b*) Frankstown or Main Branch of the Juniata River.

(*c*) Frankstown or Main Branch of the Juniata River.

(*d*) Springfield Branch.

XXI. Morrison's Cove Branch P. R. R.

STATIONS.	Above Tide.	Ocean Level.	
Hollidaysburg.....(XIX)	936	943	
Draw Bridge	935	942	
Juniata River (*e*)	935	942	
Reservoir	960	967	
Catfish	961	968	
Riddle's Lane	966	973	
Brooks Mill	999	1006	
McKee's Gap (*f*)	1029	1036	
Martha Furnace	1047	1054	
Hammond's	1126	1133	
Roaring Spring Junction..(XXII)	1199	1206	
Erb's Summit	1347	1354	
Martinsburg Junction	1337	1344	
Martinsburg	1359	1366	
Henrietta Junction	1384	1391	
Mathew's Summit	1465	1472	
Nicodemus' Summit	1425	1432	
Clover Creek	1385	1392	
Henrietta Ore Bank	1402	1409	
End of Road (*g*)	1415	1422	

XXII. Bloomfield Branch P. R. R.

STATIONS.	Above Tide.	Ocean Level.	
Roaring Spring (*h*).....(XXI)	1196	1203	
Trestle, No. 1	1214	1221	
Trestle, No. 2	1351	1358	
Bloomfield (*i*)	1453	1460	

XXIII. Springfield Branch P. R. R.

STATIONS.	Above Tide.	Ocean Level.	
Williamsburg R. R. Junc....(XX)	874	881	
Trestle, No. 1	961	968	
Goods	999	1006	
Davis Summit	1372	1379	
8th Mile Post (*j*)	1367	1374	

(*e*) Frankstown Branch of the Juniata River.

(*f*) Through Dunning's Mountain.

(*g*) In Leather Cracker Cove, the southern end of Morrison's Cove.

(*h*) Junction of this branch with Morrison's Cove Branch R. R. XXI.

(*i*) Iron Mines and Furnaces.

(*j*) This R. R. ascends from the Juniata River to the Springfield Ore Mines in Canoe Valley, the northeast prolongation of Morrison's Cove.

XXIV. Ebensburg and Cresson R. R.

The elevations on the Ebensburg and Cresson Railroad were copied from a profile in the office of the Pennsylvania R. R. Company, in Philadelphia.

The datum is mean high water at the Schuylkill Bridge, to which are added seven feet to reduce to mean Atlantic Ocean Level.

STATIONS.	Above Tide.	Ocean Level.	
Cresson R. R. Junction (*a*)....(I)	2021	2028	
Plank Road Crossing.....	2032	2039	
Lilly	2023	2030	
O'Harra.....	2008	2015	
Durbin	1920	1927	
Sander's.....	2012	2019	
Bradley's	2111	2118	
Dam (*b*).....	1953	1960	

(*a*) The Junction with Pa. R. R. is not *at* Cresson 2010′ (2017′) but *near* Cresson 2021′ (2028).

(*b*) This is the last point on the profile where the elevation is given.

XXV. Blairsville and Indiana Branch P. R. R.

The elevations on the Blairsville and Indiana Branch of the Pennsylvania R. R. were taken from a profile in the office of the P. R. R. Company, at Philadelphia.

The datum is high tide Schuylkill River, at the Philadelphia Market Street Bridge. To this seven feet are added in the second column to reduce to mean Atlantic Ocean Level.

STATIONS.	Above Tide.	Ocean Level.	
R. R. Junction (*a*).....(I)	1104	1111	
Pennsylvania Canal	958	965	
R. R. Junction (*b*).....	970	977	
Blairsville (*c*)	1004	1011	
Smith's Summit.....	1096	1103	
Wier's Run	963	970	
Black Lick	956	963	
Water Station	959	966	
Black Lick Bridge.....	1075	1082	
Doty's Bridge	1004	1011	
Rough's.....	1021	1028	
Saw Mill Run.....	1009	1016	
Bell's Mill's Run.....	1025	1032	
Phillips' Summit.....	1037	1044	
Kissinger's Summit	1048	1055	
Two Lick Creek	1037	1044	
Reed's	1138	1145	
Indiana Terminus.....	1304	1311	

(*a*) With the Main line Pennsylvania R. R. on the side of Chestnut Ridge, high above the bed of the river.

(*b*) With the Indiana and Blairsville Branch

(*c*) Market Street Station, in Blairsville.

XXVI. West Penn R. R.

The levels of the West Penn R. R. were copied from a profile in the office of the Pennsylvania R. R. Company, at Philadelphia.

The datum is mean high tide in the Schuylkill River, at Philadelphia. In the second column seven feet are added to reduce to mean Atlantic Ocean Level.

This Railroad follows down the valley of the Kishkiminitas from Blairsville to Freeport, sometimes using the bed of the old State Canal.

STATIONS.	Above Tide.	Ocean Level.	
Blairsville (*a*).....XXV	1004	1011	
Livermore.....	938	945	
Saltzburg (*b*)	884	891	
Fairbank's (*c*).....XXVII	926	933	
Helma	1010	1017	
Salina.....	948	955	
North West.....	887	894	
Roaring Run	823	830	
Apollo	816	823	
Townsend's Summit	880	887	
Grinder's	820	827	
Hill's Mill.....	773	780	
A. V. R. R. Crossing (*d*).....	778	785	
Freeport (*e*).....XXVIII	763	770	
Sligo.....	768	775	
Karn's	761	768	
Natrona.....	761	768	
Tarentum.....	750	757	
Bailey's Run	746	753	
Springdale	742	749	
Harmersville	736	743	
Fairview	734	741	
Ross	738	745	
Sharpsburg (*f*)	732	739	
Bennett's.....	734	741	
Duquesne Borough.....	734	741	
Allegheny City (*g*).....	736	743	
Allegheny City (*h*)	738	745	
Allegheny City (*i*).....	736	743	
Terminus (*j*)	734	741	

(*a*) Market Street Station, Blairsville.

(*b*) Market Street, Saltzburg.

(*c*) Coal R. R. here connects, see next table XXVII.

(*d*) Crossing Allegheny Valley R. R.

(*e*) Second Street, Freeport.

(*f*) Main Street, Sharpsburg.

(*g*) Sycamore Street, Allegheny City.

(*h*) Chestnut Street, Allegheny City.

(*i*) East Lane, Allegheny City.

(*j*) Opposite Pittsburgh and connecting with the Pittsburgh, Fort Wayne and Chicago R. R. lines.

XXVII. Branch of W. P. R. R.

The levels on the Branch of the West Penn Railroad from Fairbank's Station to the Coal Mines were furnished by Mr. George W. Leuffer, C. E. The datum 0 is at grade of W. P. R. R., Fairbank's Station.

STATIONS.	Above Tide.	Ocean Level.	
Fairbank's Junction.....XXVI	926	933	
Grade near Mines.....	1111	1118	
Bottom of Coal Bed.....	1133	1140	

XXVIII. Butler Branch W. P. R. R.

The levels on the Butler Branch Extension of the West Penn R. R. were furnished by Mr. Antes Snyder, Engineer, Springdale, Allegheny County, Pa.

There is an unexplained difference of 29.5 feet between the Butler Branch R. R. grade and the West Penn R. R. grade at Freeport, where they ought to be the same.

Another list was obtained from Mr. J. M. C. Creighton, differing very slightly from Mr. Snyder's; but still leaving *an unexplained difference of 27 feet at Freeport.*

The second column in the first table gives Mr. Snyder's levels *let down* 29½ *feet*, and in the second table Mr. Creighton's levels let down 27 feet.

The third column has seven feet added to reduce to mean Atlantic Ocean Level.

The datum of both tables is called "Mid Tide" at Philadelphia, which would require an addition of only 3.349 feet (instead of 7) to his original figures. See foot note on page 64. But this "Mid-Tide" may be a mistake for the "Mean High Tide" of the Pennsylvania R. R. Company's datum and is so taken.

STATIONS.	Mid Tide Philada.	2d Column.	Ocean Level.	
Freeport Junc....XXVI	792.5†	763‡	770	
Buffalo.....	792.5	763	770	
Monroe.....	865.5	836	843	
Sarver's.....	1056	1026.5	1034.5	
Saxon.....	1254.5	1225	1232	
Delano.....	1255.5	1226	1233	
Dilke's.....	1335	1305.5	1313.5	
Summit ‖.....	1344.5	1315	1322	
Great Belt City.....	1286.5	1257	1264	
Summit §.....	1328	1298.5	1306.5	
Herman.....	1323.5	1394	1301	
Bunker's.....	1285.5	1256	1263	
Butler.....A	1031.5	1002	1009	

† Levels furnished by Mr. Antes Snyder.

‡ Elevation on profile of West Penn R. R. at Freeport.

‖ West of Dilke's.

§ East of Herman.

STATIONS.	Mid Tide Philada.	2d Column.	Ocean Level.	
Freeport Junc....XXVI	790†	763‡	770	
Buffalo	788	761	768	
Harbison	824	797	804	
Monroe	862	835	843	
Sarver's	1052	1025	1032	
Saxonberg	1227	1200	1207	
Delano	1252	1225	1232	
Dilke's	1337	1310	1317	
Great Belt	1285	1258	1265	
Herman	1318.50	1291	1298	
Bunker	1288.38	1261	1268	
Butler.....B	1030	1003	1010	

XXIX. Ligonier Valley R. R

The levels on the Ligonier Valley R. R. were copied from notes in possession of Mr. George L. Miller, C. E., Pittsburgh, Pa. The datum is Pennsylvania R. R. at Latrobe. To which add 144 for high tide at Philadelphia.

STATIONS.	Above Tide.	Ocean Level.	
Ligonier	1144	1151	
Mill Creek.....(Surface of water)	1131	1138	
Coal Pit Run	1132	1139	
Schriner's Run	1127	1134	
Turnpike Crossing (*a*)	1123	1130	
Butler Milk Falls (*b*)	1123	1130	
Baker's Saw Mills (*c*)	1117	1124	
Little Rock Hollow	1096	1103	
Big Rock Hollow	1080	1107	
Kellog's Hollow	1068	1075	
Iron Ore (*d*)	1040	1047	
Johnson's Forge	1036	1043	
Derry Road Crossing	1030	1037	
Mitchell's Run (*e*)	1029	1036	

XXX. S. W. Pennsylvania R. R.

The levels of the South West Pennsylvania R. R. were furnished by Mr. G. W. Leuffer, Engineer.

The datum or base of levels is ordinary High Tide at Philadelphia.

† Elevations furnished by Mr. J. M. C. Creighton, Superintendent, West Penn. Division, Pennsylvania R. R.

‡ Elevation on profile of West Penn R. R. at Freeport.

(*a*) Greensburg and Stoystown.

(*b*) Loyalhanna Creek.

(*c*) At a point opposite Baker's Saw Mills.

(*d*) Out-crop of iron ore on line of R. R. 7 miles from Ligonier and 3 miles from Latrobe.

(*e*) Near Latrobe on the Pennsylvania R. R. Table I.

STATIONS.	Above Tide.	Ocean Level.	
Greensburg Junction (*a*).....I	1093	1100	
East Greensburg.....	1055	1062	
Huffs.....	994	1001	
County Home.....	972	979	
Fosterville.....	960	967	
Youngwood.....	950	957	
Jack's Run,.....	947	954	
Paintersville.....	945	952	
Sewickley Creek.....	936	943	
Hunker's.....	938	945	
Bethany.....	1044	1051	
Tarr's.....	1092	1099	
Stoner's Summit.....	1138	1145	
Hawk Eye.....	1060	1067	
Scottdale.....	1035	1042	
Jacob's Creek.....	1027	1034	
Everson.....	1027	1034	
Valley Works.....	1068	1075	
Pennsville Summit.....	1086	1093	
Pennsville.....	1047	1054	
Davidson.....	891	898	
Connellsville.....	908	915	

(*a*) Junction with Pennsylvania R. R. near Greensburg.

XXXI. Yohiogheny R. R.

The elevations on the Yohiogheny R. R. were copied from notes in the possession of Mr. John F. Wolf, Engineer Pennsylvania Gas Coal Co., Irwin's Station, Westmoreland County, Pa.

The datum is Pennsylvania R. R. at:

STATIONS.	Above Tide.	Ocean Level.	
Irwin's Stat. P. R. R. (*a*).....I	877	884	
Shaft No. 2.....	986	993	
Tunnel.....	1104	1111	
Chamber's.....	1075	1082	
McGrew's.....	974	981	
Millgrove.....	926	933	
Little Sewickley (*b*).....	797	804	
Marchand's (*c*).....	763	770	
Yohiogheny (*d*).....	776	783	
Sewickley Station (*e*).....	773	780	
R. R. Junction (*f*).....	761	768	

(*a*) Junction with Pennsylvania R. R. at Irwin's Station.
(*b*) First Crossing Little Sewickley Creek.
(*c*) Yohiogheny Mine, No. 1, Shaft No. 3, elevation of Coal, 720′.4 above Tide.
(*d*) Yohiogheny Mine, No. 2, elevation of Coal 776′.4 above Tide.
(*e*) Mine No. 4, elevation of Coal opening at this point 800′.4 above Tide.
(*f*) Junction with Pittsburgh and Connellsville R. R.

II. READING SERIES.

L. Philadelphia and Reading R. R.

The elevations at the following points on the Philadelphia and Reading Railroad and Branches, were furnished by Mr. Wm. Lorenz, Chief Engineer.

The number of stations given in the tables, are few, but no others could be obtained.

The datum is *mid tide* at Philadelphia.

To this must be added 3.349 feet to reduce to Atlantic Ocean Level.

STATIONS.	Mean Tide.	Ocean Level.	
Philadelphia (*a*)			
Nicetown Summit (*b*).....LI	111	114	
Belmont			
West Falls.....			
Pencoyd			
West Manayunk.....			
Mill Creek.....			
West Spring Mill			
West Conshohocken.....			
Swede Furnace			
Bridgeport (*c*).....LII			
Merion.....			
Port Kennedy (*c*).....LII			
Valley Forge			
Perkiomen Junction (*d*).....LIV			
Phœnixville (*e*).....LIII	105	108	
Mingo.....			
Royer's Ford.....			
Limerick			
Pottstown (*f*).....LV	146	149	
Douglassville			
Monocacy			
Birdsboro (*g*).....	170	173	
Exeter			
Neversink.....			
Reading (*h*)...LVI, LVII, LVIII, LIX.....	264	267	
Tuckerton.....			
Leesport.....	292	297	
Mohrsville			
Shoemakersville			
Hamburg.....	361	364	
Port Clinton (*i*).....LXII	397	400	
Auburn (*j*).....LXIII	457	460	
Landingville.....			
Schuylkill Haven (*k*).....( )	520	523	
Mount Carbon.....	591	594	
Pottsville (*l*) LXVI	603	606	

a Richmond Street Bridge, near the Coal Depots on the Delaware River.

b In Philadelphia, near the Germantown Road. The Germantown R. R.

LI. Germantown and Norristown Branch P. & R. R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Philadelphia (*a*).....I	39	42	
Nicetown (*b*).....	132	135	
Columbia Avenue.....See below			
New York Junction..			
Tioga			
Wayne			
Fisher's.....			
Duey's (or Wistar Street).....			
Shoemaker's.....			
Church Lane.....			
Germantown Depot (*m*).....	212	215	
Chestnut Hill	404	407	
Philadelphia.....			
Columbia Avenue .....See above	39	42	
New York Junction.....			
East Falls.....			
School Lane.....			
Wissahickon			
Schur's.....			
Manayunk			
Springfield.....			
Shawmont.....			
Princeton			
Lafayette.....			
Spring Mill			
Conshohocken			
Potts Landing.....			
Magee's.....			
Norristown (*n*).....CIII	62	65	

crosses the P. & R. R. R. in Nicetown on a bridge at an elevation of 132 (135). feet; but not at this summit. Table LI.

c Norristown opposite Bridgeport is given in this list as 62 (65.) See Table LI. Bridgeport is at the Junction of the Chester Valley R. R. See Table LII. R. R. to King of Prussia; no levels furnished.

d Perkiomen R. R.

e Pickering Valley R. R.

f Colebrookdale R. R.

g Wilmington and Reading R. R.

h Lebanon Valley R. R. Reading and Columbia R. R. East Penn R. R.

i Little Schuylkill R. R.

j Schuylkill and Susquehanna R. R.

k West Branch R. R.

l Mill Creek R. R. Schuylkill Valley R. R.

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a Depot at the corner of 9th and Green Streets.

b Crosses the P. & R. R. R. on a bridge, but not at the Nicetown Summit mentioned in Table L.

m Probably the old Depot.

n The N. Penn. R. R. level, Stony Creek branch, is 50 (62 Ocean level).

LII. Chester Valley Railroad

The levels on the Chester Valley Railroad, were furnished by Mr. W. H. Holstein, Secretary of the Chester Valley Railroad Company.

The road connects with the Philadelphia and Reading Railroad at Bridgeport, and with the Pennsylvania R. R. at Downingtown.

The base of the levels is *mid tide* at Philadelphia. Add 3.349 to reduce to Ocean level.

STATIONS.	Mean Tide.	Ocean Level.	
Bridgeport (*a*).....L	73	76	
Shainlines.....	133	136	
Henderson's.....	162	165	
King of Prussia.....	187	190	
Centreville	199	202	
Gardens.....	222	225	
Howellville.....	218	221	
Paoli Road.....	235	238	
Cedar Hollow.....	243	246	
Lee's.....	276	279	
Valley Store.....	292	295	
Mill Lane	312	315	
White Horse.....	336	339	
Exton.....	321	324	
Oakland.....	298	301	
Baldwin's.....	296	299	
Downingtown (*b*).....I	264	267	

LIII. Pickering Valley R. R.

Of this line only one level was furnished.

Datum (Reading R. R.) mean tide at Philadelphia. Add 3.349 for Ocean level.

STATIONS.	Mean Tide.	Ocean Level.	
Phœnixville L	(105)	(108)	
French Creek.....			
Kimberton			
Pikeland			
Chester Springs			
Cambria.....			
Byer's Eagle Summit.....	450	453	

a Opposite Norristown, Table L.

b On the Pennsylvania R. R.

LIV. Perkiomen R. R.

STATIONS.	Mean Tide.		
Perkiomen Junction (*a*).....L			
Oaks.....			
Doe Run			
Yerke's			
Collegeville...	151	154	
Rahn's.....			
Grater's Ford			
Skippack			
Schwenksville	149	152	
Green Land	245	248	
Emaus Junction (*b*).....LXI			

a Reading R. R.
b East Penn R. R.

LV. Colebrookdale R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Pottstown (*a*).....L	(146)	(149)	
Glasgow			
Manatawny.....			
Iron Stone			
Colebrookdale			
Boyertown	388	391	
New Berlin			
Bechtelsville			
Mt. Pleasant.....	466	469	
Rittenhouse Gap.....			
Alburtis (*b*).....LXI	(427)	(430)	

a Reading R. R.
b East Penn R. R.

LVI. Wilmington and Reading R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Reading.....L	(264)	(267)	
Birdsboro (*a*).....L	(170)	(173)	
Springfield.....			
Coatesville (*b*).....I			
Chadd's Ford (*c*).....			
Wilmington (*d*).....			

a Junction with Philadelphia and Reading R. R.
b Crosses Pennsylvania R. R.
c Crosses Philadelphia and Baltimore R. R.
d Connects with Philadelphia, Wilmington and Baltimore R. R.

LVI. Wilmington and Reading R. R.

These levels of the Wilmington and Reading R. R. were furnished by Mr. E. Collings, Superintendent.

The datum, or base of levels, is low tide at Wilmington, Del. Relation of Ocean Level to this datum is unknown.

STATIONS.	Low Tide.	Ocean Level.	
Birdsboro Junction (*a*).....L	173	(173)	
Hampton.....	223		
White Bear.....	349		
Geigertown.....	432		
Cold Run.....	525		
Joanna.....	627		
Springfield.....	645		
Conestoga.....	647		
Isabella.....	639		
E. B. & W. R. R. Crossing (*b*)..II	647		
Beaver.....	603		
Honeybrook.....	596		
Manor.....	572		
Hibernia.....	530		
Brandywine.....	556		
Coatesville (*c*).....I	315		
Modena.....	278		
Mortonville.....	260		
Laurel.....	241		
Embréiville.....	231		
Glen Hall.....	218		
Northbrook.....	209		
Seeds.....	195		
Lenape.....	183		
Pecopson.....	180		
Chadd's Ford.....	175		
Smith Bridge.....	209		
Centre.....	263		
Dupont's.....	282		
Wilmington.....	12	(12)	

a Junction with Philadelphia and Reading R. R. at Birdsboro, Berks County, Pennsylvania.

b Junction with E. Brandywine and Waynesburg R. R., Chester County, Pa.

c The Pennsylvania R. R. track on bridge just west of Coatesville Station is 62′ higher than track on W. & R. R. R. The elevation on Pennsylvania R. R. at the point where it crosses the W. & R. R. R. is 374′ above tide. By deducting 62′ according to Pennsylvania R. R. datum the elevation would be 312′. The datum of the Pennsylvania R. R. is high tide in Schuylkill River. The datum of W. & R. R. R. is low tide at Wilmington.

LVII. Lebanon Valley R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Reading (*a*).....L	(264)	(267)	
Schuylkill Bridge.....	262	265	
Sinking Springs (*b*).....LVIII	(341)	(344)	
Wernersville.....	376	379	
Heidelburg.....	376	379	
Robesonia.....	428	431	
Sand Holes Summit.....	450	453	
Womelsdorf.....	433	436	
Smiths'.....	425	428	
Missimer's.....	425	428	
Richland.....	420	423	
Myerstown.....	460	463	
Prescott.....	503	506	
Avon.....	467	470	
Lebanon.....	456	459	
C. R. R. Junction (*c*).....LX	444	447	
L. & T. R. R. Junction (*d*)...LIX	439	442	
Annville.....	436	439	
Palmyra.....	443	446	
Spring Creek.....	384	387	
Hummelstown.....	360	363	
Swatara Creek.....	355	358	
Swatara Hills Summit.....	428	431	
Rutherford's.....	425	428	
Paxton.....	363	366	
Harrisburg (*e*).....I	308	311	

a Reading R. R.
b Reading and Columbia R. R.
c Cornwall R. R. Junction.
d Lebanon and Tremont R. R. Junction.
e West Line of Lebanon Valley Depot, Harrisburg, which, however, according to Pennsylvania R. R. Table I, is 315.5; probably more correct than 308.

LVIII. Reading and Columbia R. R.

STATIONS.	Above Tide.	Ocean Level.	
Reading.....L	(264)	(267)	
Sinking Springs (*a*).....LVII	341	344	
Deep Cut (*b*).....	566	569	
Fitztown.....			
Reinhold's.....			
Union.....			
Ephrata.....	378	381	

a Junction with the Lebanon Valley Road.
b South Mountain Summit.

LVIII. Reading and Columbia R. R.—CONTINUED.

STATIONS.	Above Tide.	Ocean Level.	
Rothville Summit (*c*)	401	404	
Litiz			
Manheim			
Sellers			
Lancaster Junction			
Landisville (*d*) I	397	400	
Bruckhart's			
Ironville			
Kauffman's			
Chestnut Hill Summit	582	585	
Columbia (*e*) I	257	260	

c This summit comes in *somewhere* between Ephrata and Landisville.

d Crosses Pennsylvania R. R. *on grade.* It is given as 398 (405) in Table I, — a difference in the *Ocean Level* column of (5) feet.

e The Pennsylvania *Ocean Level* grade here is (251) at the depot on the street, lower down on the hill slope.

LIX. Lebanon and Tremont R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Lebanon Junction (*a*) LVII	(439)	(442)	
Heilmansdale	505	508	
Bunker Hill			
Jonestown			
Union Forge			
Swatara Gap			
Murray			
Mifflin			
Irving			
S. & S. R. R. Junc. (*b*) LXIII	491	494	
Pinegrove			
L. G. Ex. R. R. Junc. (*c*) .... (..)			
Tremont (R. R. Junc.) (*d*) ... (..)			
Donaldson	901	904	
Kalmia Colliery	1128	1131	

LX. Cornwall R. R.

NOTE.—The levels on the Cornwall Railroad were copied from a profile furnished by Mr. A. Wilhelm, President of the Company.

Reading R. R. datum, Mean Tide at Philadelphia. Add 3.349 feet for ocean level.

Lines have been surveyed south to Mount Hope, and to Manheim.

a Lebanon Valley R. R.
b Schuylkill and Susquehanna R. R.
c Lorberry Gap Extension R. R.
d Mine Hill R. R.; Lyken's Valley R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Lebanon Junction (*a*).....LVII	444	447	
Cumberland Street.....	425	428	
Plank Road.....	438	441	
Killian's Road.....	534	537	
Coleman's Road.....	534	537	
Furnace Run.....	539	542	
Cornwall (*b*).....	576	579	

a Junction with Lebanon Valley R. R. near Lebanon.
b Opposite the Middle of the Ore Hill.

LXI. East Penn R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Reading (*a*).....L	(264)	(267)	
Temple.....			
Blandon.....	405	408	
Fleetwood.....			
Lyons.....	460	463	
Bower's.....			
Topton Junction (*b*).....	471	474	
Mertztown.....			
Shamrock.....			
Alburtis Intersection (*c*).....LV	427	430	
Millerstown.....			
Emaus Station (*d*).....LIV	417	420	
Penn Junction (*e*).....	260	263	
Allentown.....			

a Reading R. R.
b Branch R. R. to Kutztown.
c Fogelsville R. R.—Colebrookdale R. R.
d Perkiomen R. R.
e Lehigh Valley R. R., just below Allentown, where the 260 (263) elevation is supposed to apply.

LXII. Little Schuylkill R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Port Clinton (*a*).....L	(397)	(400)	
Drehersville.....			
Ringgold.....	541	544	
Hecla.....			
Reynolds.....			
Tamaqua (*b*).....	787	790	

a Reading R. R.
b South side of Broad Street.—Mountain Link and Schuylkill Valley R. R. —East Mahanoy R. R.

LXIII. Schuylkill and Susquehanna R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Auburn Junction (*a*).....L	(457)	(460)	
Jefferson.....			
Summit.....			
White Horse.....			
Stanhope.....			
Pinegrove Junction.....	511	514	
L. & P. R. R. Junction (*b*)..LIX	(491)	(494)	
Ellwood.....			
Gold Mine.....			
Rausch Gap.....			
Cold Spring.....			
Yellow Spring.....			
Rattling Run.....			
Forge.....			
Dauphin (*c*).....			
Rockville (*d*).....I	(343)	(350)	

a Reading R. R.
b Lebanon and Pinegrove R. R., or Lebanon and Tremont.
c East side of the Susquehanna River.
d East side of Susquehanna River, crossing Pennsylvania R. R. at grade, at the east end of the long bridge, 5 miles above Harrisburg.

LXIV. Mine Hill and Schuylkill Haven R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Schuylkill Haven (*a*).....L	(520)	(523)	
Westwood Junction.....	654	657	
Summit.....	860	863	
Tremont.....	758	761	
Westwood Junction, as above....	(654)	(657)	
Minersville.....	684	687	
Mine Hill Gap.....	816	819	
Glen Carbon.....	1136	1139	
Head of Mine Hill Plane, No. 1..	1519	1522	
Foot of Gordon Plane.....	773	776	
Centralia.....CXV	1465	1468	
Potts Colliery, Locust Dale.....	1095	1098	

a Junction with Philadelphia and Reading R. R.

LXV. Catawissa and Williamsport R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Tamaqua (*a*).....LXVIII	(787)	(790)	
East Mahanoy Junction (*b*).....	(1093)	(1096)	
Tamenend (*c*).....	1291	1294	
Quakeake Junction (*d*).....CXV	1350	1353	
Summit	1542	1545	
Girard.....			
Girard Passing.....			
Brandonville.....			
Ringtown	1332	1335	
Beaver.....			
McAuley	759	762	
Mainville.....	674	677	
D. W. & H. R. R. (*e*).....CXVI	476	479	
Catawissa	474	477	
North Branch (*f*).....	481	484	
Rupert (*g*)			
Danville.....	493	496	
Mooresburg.....			
Pottsgrove.....	494	497	
Dougal	501	504	
Milton.....			
P. & E. R. R. Crossing (*h*) CCXIII	480	483	
Datesman's.....			
West Branch (*i*).....	475	478	
New Columbia.....			
White Deer.....	486	489	
Allenwood.....			
Fritz.....			
Montgomery			
P. & E. R. R. Crossing (*j*) CCXIII	500	503	
Susquehanna River (*k*).....	505	508	
Muncy	504	507	
Hall's.....	521	524	
Montoursville.....	534	537	
Loyalsock Creek (*l*)	535	538	
P. & E. R. R. Crossing (*m*) CCXIII	542	545	
Williamsport Depot (*n*).....	530	533	

a b East Mahanoy R. R.
c Junction with Lehigh and Susquehanna Division of Central R. R. of N. J.
d With Lehigh Valley R. R.
e Crossing Danville, Hazelton and Wilkesbarre R. R. below Catawissa.
f Susquehanna River, water 29′ below rail.
g Junction with Lackawanna and Bloomsburg R. R.
h Crossing P. & E. R. R. (Milton).
i Susquehanna River, West Branch, water 28′ below rail.
j Crossing P. & E. R. R. (Montgomery).
k Water 30′ below rail.
l Water 13′ below rail.
m Crossing P. & E. R. R. (Williamsport).
n The level of the Philadelphia and Erie R. R. at this point is given in Table CCXIII, as 510.43 feet above Ocean Level.

LXVI. Mill Creek R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Pottsville (*a*).....L	(603)	(606)	
Mount Carbon (*a*).....L	(591)	(594)	
Mill Creek Junction.....	622	625	
Port Carbon (*b*).....LXVII	627	630	
Dormer's			
St. Clair.....			
Lanigan Furnace.....	706	709	
John's Mines.....	827	830	
New Castle.....	875	878	
Head of Grade.....			
Frackville.....			

a a Philadelphia and Reading R. R.
b Junction with Schuylkill Valley R. R.

LXVII. Schuylkill Valley R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Pottsville (*a*).....L			
Mt. Carbon (*a*).....L			
Port Carbon (*b*).....LXVI			
Eagle Hill.....			
Cumbola.....			
New Philadelphia			
Middleport.....	712	715	
Brockville.....			
Tuscarora.....	895	898	
Newkirk.....			
Tamaqua (*c*).....LXII	(787)	(790)	

a a Philadelphia and Reading R. R.
b Junction with Mill Creek R. R.
c Junction with Little Schuylkill R. R.

LXVIII. East Mahanoy R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Tamaqua (*a*).....LXII, LXV	(787)	(790)	
East Mahanoy Junction.... LXV	1093	1096	
" " Tunnel, south end	1312	1315	
" " " north end	1334	1337	
Mahanoy City Depot.....CXV	1235	1238	

a End of Little Schuylkill R. R. Catawissa and Williamsport R. R.

LXIX. Mahanoy and Shamokin R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Head of Grade (*a*)	1472	1475	
Head of Mahanoy Plane	1479	1482	
Foot of Mahanoy Plane	1127	1130	
St. Nicholas Colliery	1155	1158	
New Boston Colliery	1520	1523	
Ashland Depot	881	884	
Summit	1155	1158	
Keystone	1025	1028	
Benjamin Franklin Colliery	1175	1178	
Locust Summit	1238	1241	
Monteliers Colliery	1072	1075	
Coal Ridge Colliery, No. 2	1131	1134	
Preston Colliery, No. 1	1090	1093	
Cuyler Colliery, Raven Run	1360	1363	
Girardville	1051	1054	
Shenandoah City Depot	1244	1247	
Head of Big Mine Run Plane	1275	1278	
Locust Gap Junction	1029	1032	
Greenback Colliery	895	898	
Shamokin Depot	730	733	
Trevorton Colliery	760	763	
Herndon Junction (*b*)	423	426	

a South side Broad Mountain Summit.

b Junction with Northern Central R. W. at Herndon Station, 13½ miles from Trevorton.

NOTE. There are scores of small branching colliery roads and tracks to coal mines not mentioned in the foregoing tables. Civil and mining engineers in the Coal Region are earnestly requested to furnish all the authentic levels of the intersections of such roads, levels of switches, levels of mouths of gangways, and levels of determinate recognizable points on the surface, high and low, in their possession, to make this portion of the hypsometrical records of Pennsylvania as complete and useful as possible. [J. P. L.]

LXX. Schuylkill Canal.

The elevations on the Schuylkill Canal, were copied from a list furnished by Mr. James F. Smith, Chief Engineer, Reading, Penna.

The datum is mid tide, Philadelphia. The levels are deduced from a survey made in 1846.

Schuylkill Navigation Company. Elevation of Combs of Dams.

NAMES OF DAM.	No.	Above Mid-Tide.	Ocean Level.	Name of Town.
Fairmount	32	10	13	
Flatrock	31	36.10	39	
Plymouth	30	45.87	49	Conshohocken.
Norristown	29	57.36	60	
Catfish	28	62.19	65	
Pawlings	27	66.49	69	Perkiomen.
Black Rock	26	84.61	88	Phœnixville.
Vincent	25	102.07	105	
Lewis	24	177.86	181	
Poplar Neck	23	184.88	188	Lower Reading.
Kissingers	22	204.38	207	
Shepps	21	213.09	216	
Leizes	20	221.46	224	
Felix's	19	236.27	240	
Herbine's	18	265.95	269	Leesport.
Kernsville	17	364.93	368	
Blue M'tn.	16	389.83	393	
Hummels	15	409.03	412	
Lords	14	432.98	436	
Cross Cut	13	443.93	447	Auburn.
Dam No.	12	451.23	454	
" "	11	471.53	475	
" "	10	476.93	480	
" "	9	483.33	486	
" "	8	490.63	494	
" "	7	509.23	512	Schuylkill Haven.
" "	6	551.38	554	
" "	5	574.36	577	Second Mountain.
" "	4	583.83	587	Mount Carbon.
" "	3	592.23	595	" "
" "	2	613.83	617	Palo Alto.
" "	1	618.63	622	Port Carbon.

NOTE.—Levels as taken from a profile in the Penna. Canal Co.'s Office, at Harrisburg, made under the direction of J. Dutton Steele, Civil Engineer, in 1851.

TOWNS.	Above Tide.		
Mount Carbon	620		
Schuylkill Haven	511		
Port Clinton	392		
Reading	195		
Pottstown	147		
Norristown	49		

LXXI. Union Canal.

The elevations on the Union Canal, were copied from a statement, giving number and lifts of locks, furnished through the kindness of Mr. B. B. Lehman, of Lebanon, Pa., formerly Chief Engineer and Genral Superintendent of the Union Canal.

Elevation of Locks on Union Canal from Lebanon, Eastward.

NO. OF LOCK.	Above Tide.	Ocean Level.	
Lock No. 1	475.50		
" 2	471		
" 3	466.50		
" 4	462		
" 5	457.50		
" 6	453		
" 7	447.50		
" 8	440.50		
" 9	433.50		
" 10	427.50		
" 11	421.50		
" 12	414.50		
" 13	407.50		
" 14	401.50		
" 15	395.50		
" 16	387.50		
" 17	379.50		
" 18	373.50		
" 19	368.50		
" 20	362.50		
" 21	356.50		
" 22	351.50		
" 23	346.50		
" 24	340.50		
" 25	334.50		
" 26	328.50		
" 27	322		
" 28	315.50		
" 29	310.50		
" 30	305.50		
" 31	300.50		
" 32	295.50		
" 33	290.50		
" 34	285.50		
" 35	280.50		
" 36	275.50		
" 37	269.50		
" 38	264.50		
" 39	258.50		
" 40	253.50		
" 41	247.50		
" 42	241.50		
" 43	235.50		
" 44	230.50		
" 45	225.50		
" 46	220.50		
" 47	215.50		
" 48	210.50		
" 49	205.50		
" 50	200.50		
" 51	192.50		
" 52	185.50		
" 53	179		
" 54	169		

Lebanon (or Summit Level Union Canal) 480
Middletown (Mouth of Swatara Creek) 266
Reading (Schuylkill River) 169
Pinegrove (Basin at former head of Navigation) 483½

Elevation of Locks on Union Canal from Lebanon, Westward.

NO. OF LOCK.	Above Tide.	Ocean Level.	
Lock No, 1	474.60		
" 2	469.20		
" 3	463.80		
" 4	458.40		
" 5	453		
" 6	447.60		
" 7	442.20		
" 8	436.80		
" 9	431.40		
" 10	426.		
" 11	420.60		
" 12	415.20		
" 13	409.80		
" 14	404.40		
" 15	399		
" 16	393.60		
" 17	384.60		
" 18	376.60		
" 19	368.60		
" 20	362.60		
" 21	356.60		
" 22	351.10		
" 23	345.60		
" 24	340.10		
" 25	334.60		
" 26	329.60		
" 27	324.60		
" 28	319.60		
" 29	314.60		
" 30	309.60		
" 31	303.60		
" 32	297.60		
" 33	291.60		
" 34 (At Middletown)	285.60		
Susquehanna River } Mouth of Swatara Creek }	266		

LXXII. Lebanon Valley R. R. (*Steele.*)

NOTE.—This list was copied from a profile in the office of the Pennsylvania Company, at Harrisburg, made under the direction of J. Dutton Steele, Civil Engineer, in 1857.

STATIONS.	Above Tide.	Ocean Level.	
Harrisburg I	314		
Hummelstown.....	362		
Palmyra	442		
Annville.....	395		
Lebanon	460		
Myerstown	468		
Womelsdorf	440		
Reading	253		
Birdsboro.....	165		
Pottstown.....	137		
Phœnixville.....	97		
Norristown.....	58		
Manayunk Falls.....	51		

III. LEHIGH SERIES.

C. North Pennsylvania R R

The levels on the North Pennsylvania R. R. were copied from the profile in the office of the Company, by permission of Mr. S. W. Roberts, Chief Engineer and General Superintendent.

The datum, or base of levels, is Philadelphia City datum, 8.733′ above mean surface of Atlantic Ocean. *Therefore 9 feet is added to make the second column.*

STATIONS.	City Datum.	Ocean Level.	
Philadelphia Depot (*a*).....	19	28	
Cohocksink	25	34	
Diamond Street.....	30	39	
Somerset Street.....	69	78	
P. & R. Coal R. R. Crossing (*b*)..L	70	79	
Tioga Street	94	103	
Frankford Lane.....	92	101	
Fisher's Lane.....	110	119	
Green Lane.....	156	165	
Oak Lane.....	192	201	
City Line.....	184	193	
York Road.....	176	185	
Cnelton Hills.....	181	190	
Paxon's Road.....	225	234	
Abingdon Junction (*c*).....CII	245	254	
Edge Hill.....	284	293	
Camp Hill.....	169	178	
Edgehillville Road.....	167	176	
Fort Washington.....	161	170	
Ambler.....	190	199	
Pennllyn.....	230	239	
Gwynedd.....	262	271	

a At Willow Street.
b Crossing Philadelphia & Reading R. R.
c Intersection of Northeast Pennsylvania R. R. at Abington.

STATIONS.	City Datum.	Ocean Level.
Wissahickon Creek	342	351
Lansdale Junc. (*d*).....CIII, CIV	359	368
Hatfield	302	311
Zetty's Road	339	348
Nigger Hill	443	452
Sellersville	322	331
Tunnel	444	453
Koffler's Gap	521	530
Bunker Hill	519	528
Quakertown	487	496
Hilltop	546	555
Coopersburg	540	549
Summit (*e*)	591	600
Koch's Mill	364	373
Yeager's Mill	339	348
Wagner's Mill	279	288
Hellertown	267	276
Hampton	267	276
Shimersville R.R. (*f*).....CV	255	264
Hess' Mill	259	268
Zinc Works	238	247
Bethlehem (*g*)	228	237

A profile in the office of the Pennsylvania Canal Company, at Harrisburg, made under the direction of J. Dutton Steele, Civil Engineer, in 1857, gives the following very different levels of some of the points mentioned in the above list, and of others not mentioned in it. Some of the names seem to have been altered or reversed:

Wingohocking (Frankford Lane?) 92; Fisher's Lane, 110; City Lane (Oak Lane?) 192; Edgehill (York Road?) 175; Edgehill, 284; Fort Washington, 158; Wissahickon (Ambler?) 190; Gwynedd, 229! North Wales, 377; Lansdale, 371; Nigger-Hill, 440; Sellersville, 311; Koffler's Gap, 524; Bunker Hill, 519; Quakertown, 489; Same's Gap, 597; Hellertown, 270; Bethlehem, 249.

The datum is "Tide."

CI. Delaware and Bound Brook R. R.

NOTE. For this road which is virtually a branch of the North Pennsylvania, leaving it at Jenkintown Station. See Appendix.

For the *Philadelphia and Newtown R. R.*, see under CLIII.

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d Doylestown Branch and Stony Creek R. R. Crosses at Lansdale.

e Highest Point noted on profile of North Pennsylvania R. R. end of section 44, near Coopersburg, 591.50.

f Point of divergence of Shimersville Branch.

g The North Pennsylvania R. R. intersects the Lehigh Valley R. R. at this point.

CII. Northeast Pennsylvania R. R.

The levels on the Northeast Pennsylvania R. R. were furnished by Mr. S. W. Roberts, Chief Engineer and General Superintendent, N. P. R. R.

Base of levels, Philadelphia City datum, 8.733 above Ocean Level. Therefore nine feet is added to make second column.

STATIONS.	City Datum.	Ocean Level.	
Abington Junction (*a*).....C	250	259	
Summit.....	333	342	
Willow Grove.....	250	259	
Heaton.....			
Pennepack Creek.....	160	169	
Fulmore.....			
Hatsborough.....	220	229	
Hartsville.....	233	242	

a Junction with the North Pennsylvania R. R. near Abington.

CIII. Doylestown Branch N. P. R. R.

The elevations on the Doylestown Branch of the North Penn R. R. were furnished by Mr. S. W. Roberts, Chief Engineer.

Base of levels, Philadelphia City datum, 8.733 above Ocean Level.

STATIONS.	City Datum.	Ocean Level.	
Lansdale Junction (*a*).....C	359	368	
Temperance Road.....	350	359	
Neshaminy Creek.....	260	269	
Road to Lexington.....	242	251	
Cooke's Run.....	242	251	
Bristol Road.....	294	303	
Doylestown (*b*).....	338	347	

a Point of divergence from N. P. R. R. at, or near Lansdale.
b Depot Ground at Doylestown.

CIV. Stony Creek R. R.

The levels on Stony Creek R. R. were copied from a profile furnished through the kindness of Mr. A. R. Roberts, Assistant Engineer, N. P. R. R.

The datum was fixed on the assumption that the elevation of the water in the Schuylkill River pool *below* Norristown, stood 49′ above Mean Tide at Philadelphia. The elevation of the comb of the dam *at* Norristown, as shown by the notes of the Schuylkill Navigation Company, at Reading, Pa., is 57.36′ above mid tide at Philadelphia,

The third column is made by adding three feet (3.349) to reduce to Mean Tide at Philadelphia to Ocean Level.

STATIONS.	Above Assumed Datum.	Mean Tide.	Ocean Level.	
Lansdale Junc. (*a*)....C	*350	†359	362	
1st Mile Post.....	350	359	362	
2d Mile Post.....	330	339	342	
Summit (*b*).....	350	359	362	
1st Crossing of Stony Cr.	215	224	227	
2d Crossing of Stony Cr.	142	151	154	
3d Crossing of Stony Cr.	104	113	116	
Norristown (*c*).....LI	50	59	62	

a With North Penn R. R. and with Doylestown Branch R. R.

* Elevation as shown on profile.

† Elevation of Railroad Crossing as shown on profile of North Penn. R. R. Levels at the other stations of the table are made to correspond with the level of North Penn R. R., by adding 9 feet to Mr. Roberts' original figures.

b Between Wissahickon and Stony Creek.

c The level given in Table LI, of the Philadelphia and Reading R. R., Germantown and Norristown Branch, at Norristown is 62 (65 Ocean Level).

CV. Shimersville Branch N. P. R. R.

STATIONS.	Above Tide.	Ocean Level.	
Junction (*a*).....C	255	258	
Junction (*b*).....CXIV	217	220	

a Point of divergence from N. P. R. R. near Bethlehem.

b Junction with Lehigh Valley R. R.

CVII. Lehigh and Susquehanna R. R.

NOTE.—This road runs on the north and east bank of the Lehigh River most of the way. Its levels are similar to those of the Lehigh Valley road on the opposite bank.

STATIONS.	Tide.	Ocean Level.	
Easton (*a*).....			
Freemansburg.....			
Bethlehem (*b*).....CXIII	(240)	(243)	
Allentown Station.....			
Catasauqua (*c*)			
Laubach's.....			
Siegfried's Bridge			
Treichler's.....			
Walnut Port.....			
Lehigh Gap			

a Junction with Morris & Essex R. R.

b Junction with N. Penna. and with Lehigh and Lackawanna R. R's.

c Junction with Cat. & Fogelsville R. R.

STATIONS.	Tide.	Ocean Level.	
Parryville			
Weissport			
Lehighton			
Mauch Chunk (*d*)			
Penn Haven Junction			
Rockport			
White Haven (*e*)			
Penobscot			
Ashley (*f*)			
Wilkesbarre			
Pittston			
Moosic			
Scranton (*g*)			
Green Ridge (*h*)			

CVIII. Mauch Chunk and Switch Back R. R.

Mauch Chunk			
Summit Hill			

CIX. Nesquehoning Valley R. R.

Mauch Chunk			
Nesquehoning			
Hauto			
Hometown			
Tamenend			

CX. Tamaqua Branch R. R.

Hauto			
Coledale			
Tamaqua			

CXI. Nescopec Branch R. R.

White Haven			
Upper Lehigh			

CXII. Nanticoke Branch R. R.

Ashley			
Sugar Notch			
Hanover			
Nanticoke			
Wanamie			

d Junction with Nesquehoning Valley Branch; M. C. Summit Hill and Switchback R. R.
e Junction with Nescopec Branch.
f Junction with Nanticoke Branch.
g Junction with Del. Lack. & Western R. R.
h Junction with Delaware & Hudson R. R.

CXIII. Lehigh and Lackawanna R. R.

The elevations on the Lehigh and Lackawanna R. R., were furnished by Mr. Charles Brodhead, President of the Company, who says, "Our surveys carry us into the *Wind Gap;* and the highest point on the Turnpike, *in the Gap*, we found to be 738 feet above Bethlehem, or 978 feet above tide." The road runs as far as Steuben, 15 miles.

STATIONS.	Mean Tide.	Ocean Level.	
Bethlehem Junction (*a*)....CVII	240	243	
Peter's Mills.....	255	258	
Shimer's.....	287	290	
Reiter.....			
Brodhead	315	318	
Steuben	333	336	
Bath	401	404	
Chapman.....	576	579	

a With Lehigh and Susquehanna R. R. at Bethlehem, on the north side of the Lehigh River.

CXIV. Lehigh Valley R. R.

The levels on the Lehigh Valley R. R. were copied from a list furnished by Mr. Robert H. Sayre, Chief Engineer and General Superintendent, Lehigh Valley R. R.

The datum is Mean Tide, Delaware River, three feet being added for Ocean Level in the second column.

Note on the Lehigh Canal Levels.

By a printed list of levels in the possession of Mr. George Ruddle, of Mauch Chunk, it appears that there is a rise in the

Lower grand section of Slackwater Navigation, from the Delaware River to Mauch Chunk (46 miles), of.	360′.87
Upper grand section, Mauch Chunk to Wright's Creek (26 miles), of.	599′.83
Upper grand section, Wright's Creek to Stoddart's Ville (miles), of.	336′.00
Adding to these figures, for the height of Bixler's Rift, Delaware Canal, above low tide in Delaware River.	160.40
we get the following heights of the Lehigh Slackwater System:	
At Mauch Chunk, 360.87 + 160.40 = ...	521.23
At Wright's Creek, 521.23 + 599.83 = ...	1121.10
At Stoddart's Ville, 1121.10 + 336 = ...	1457.10

STATIONS.	Mean Tide.	Ocean Level.	
Philipsburg (*a*).....CL	208	211	
Delaware River, here.....	(148)	(151)	
Easton	202	205	
Redington.....			
Freemansburg.....	219	222	

a 60′ above Delaware River, Junction with Central R. R. of N. J., Morris and Essex R. R., Belvidere and Delaware R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Bethlehem	231	234	
North Penn R. R. Junction (*b*).C	247	250	
East Penn R. R. Junction...LXI			
Allentown	251	254	
Catasauqua.....CXV	277	280	
Hokindauqua.....CXV *bis*			
Whitehall	297	300	
Coplay			
Laury's	326	329	
Slatington	363	366	
Lehigh Gap	385	388	
Lehighton	461	464	
Mauch Chunk (*c*).....CVIII	553	556	
Glen Onoko			
Penn Haven Junction.....CXVI	705	708	
Hickory Run			
Rockport (*d*)	910	913	
White Haven	1150	1153	
Summit (*e*)	1742	1745	
Fairview (*f*)	1675	1678	
Newport	1024	1027	
Warrior Run	710	713	
Sugar Notch	670	673	
South Wilkesbarre	550	553	
Wilkesbarre (*g*)	553	556	
Plainsville	550	553	
Pittston.....CXVIII	572	575	
Lackawanna Junction (*h*)....CLV	572	575	
Ransom	584	587	
Falls	590	593	
McKunes'	600	603	
Lagrange	600	603	
Tunkhannock.....CXIX	614	617	
Vosburg	617	620	
Mehoopany	636	639	
Meshoppen (*i*)	646	649	
Black Walnut	653	656	
Laceyville	663	666	
Wyalusing	678	681	
Frenchtown	694	697	
Rumnerfield	700	703	
Standing Stone	706	709	
Wysauking	716	719	
Towanda (*j*).....CXX	738	741	
Ulster	743	746	
Athen's Bridge	776	779	
Waverly (*k*).....CLXII	823	826	

b Junction with East Penn. R. R. Elevation given by Philadelphia and Reading R. R. at this point 260'.
c 40' above Lehigh River.
d 35' above Lehigh River.
e Nescopeck Mountain.
f Top of Wyoming Mountain.
g 30' above Susquehanna River.
h 35' above Susquehanna River, Junction with Delaware, Lackawanna and Western R. R.
i 35' above Susquehanna River at Meshoppen.
j 28' above Susquehanna River at Towanda.
k 25' above Chemung River. At Waverly joins the New York and Erie R. R.

CXV. Catasauqua and Fogelsville R. R.

The levels of the Catasauqua and Fogelsville R. R. were furnished through the courtesy of Mr. Joshua Hunt, President of the Company.

The datum is Lehigh Valley R. R. at Catasauqua; which is 277′ above tide; and therefore 280′ above Ocean Level, as shown in the second column.

STATIONS.	Above Catasauqua.	Ocean Level.
Catasauqua	0	280
Seiple's	183	463
Jordan Bridge (*a*)	165	445
Guth's	209	489
Walbert	268	548
Chapman	259	539
Trexlertown (*b*)	129	409
Spring Creek	101	381
Alburtis (*c*)	173	453
Lock Ridge	158	438
Gardner	387	667
Red Lion	511	791
Rittenhouse Gap	658	938

a Water in creek at Jordan Bridge, 81 feet = Catasauqua; 361′ = Tide.
b Allentown R. R. Crossing on grade.
c East Pennsylvania R. R. Crossing.

CXV bis. Trenton R. R.

NOTE. No levels of this road could be obtained.

CXVI. Lehigh Valley Coal Branches.

The elevations on the Branch Railroads owned by the Lehigh Valley R. R. Company were furnished by Mr. Robert H. Sayre, Chief Engineer and General Superintendent.

The datum is mean Tide, Delaware River.

STATIONS.	Mean Tide.	Ocean Level.
Penn Haven Junction (*a*)	705	708
Black Creek (*b*)	1015	1018
Weatherly	1090	1093
Hazle Creek Junction (*c*)	1325	1328
Hazleton		
Eckley		
Hazel Creek Junction (*c*)	1325	1328
Beaver Meadow	1355	1358
Lewiston		
Jeanesville	1680	1683
Yorktown Crossing (*d*)	1750	1753

a With Lehigh Valley R. R.
b Leaves here the Quakeake R. R. or Mahanoy Division.
c Of the Beaver Meadow R. R. with the Hazleton R. R.
d Divide between the Lehigh and Susquehanna waters.

STATIONS.	Mean Tide.	Ocean Level.	
Audenreid	1735	1738	
Hartz's			
Quakake Junction (*e*)	1315	1318	
Delano (*f*)	1665	1668	
Mahanoy City Junction.....LXV	1552	1555	
Mahanoy City.....LXVIII	1230	1233	
Shenandoah	1268	1271	
Raven Run			
Centralia (*g*).....LXIV	1484	1487	
Mount Carmel	1056	1059	
Locust Gap	1027	1030	
Fulton	960	963	
Shamokin (*h*)	730	733	
Zerbe Summit (*i*)	1073	1076	
Zerbe Colliery	905	908	

e Crosses at Yorktown the Catawissa R. R. Elevation (as given by Philadelphia and Reading R. R. at this point) 1350′ feet above tide!

f Delano is on the divide between Schuylkill and Susquehanna waters.

g Centralia is on the divide between the Mahanoy and Shamokin waters.

h Shamokin Station 70′ above the town.

i Zerbe Summit divides the Shamokin and Little Mahanoy waters.

CXVII. Danville, Hazleton and Wilkesbarre R. R.

The elevations on the Danville, Hazleton and Wilkesbarre R. R. were furnished by Mr. A. B. Starr, Assistant Engineer, P. & E. R. R.

The datum is *high* tide at the Schuylkill River, at Philadelphia. Add seven feet for Ocean Level.

STATIONS.	High Tide.	Ocean Level.	
Sunbury Junction (*a*)	436	443	
Kline's Grove	438	445	
Wolverton	435	442	
Kipp's Run	456	463	
Danville (*b*)	456	463	
Roaring Creek	452	459	
Catawissa	464	471	
R. R. Crossing (*c*)	463	470	
Mainville	582	589	
Mifflin Cross Roads	804	811	
Scotch Valley	1008	1017	
Summit	1030	1037	
Wolfton	1016	1023	
Rock Glen	914	921	
Gowan	992	999	
Tomhicken (*d*)	1221	1228	

a Shamokin R. R. with Northern Central R. R. at Sunbury.

b With Lackawanna and Bloomsburg R. R.

c Catawissa R. R. Crossing; Elevation of Catawissa R. R. at same point 476.

d With Lehigh Valley R. R.

CXVIII. Pennsylvania Coal Company's R. R.

Elevations on the Pennsylvania Coal Company's R. R. from Pittston (or Port Griffith) to Hawley were copied from a profile in the Company's office at Pittston, Pa., by permission of Mr. George Johnson, Engineer.

The datum is 0 at foot of Plane No. I = 567.28 above Sea Level.

	STATIONS.	Profile.	Above Tide.
	Head of Plane.....No. 1	108	675
Loaded track going out from Pittston.	" " ..... " 2	206	773
	" " ..... " 3	246	813
	" " ..... " 4	397	964
	" " ..... " 5	495	1062
	" " (Dunmore) " 6	550	1117
	" " ..... " 7	697	1274
	" " ..... " 8	888	1455
	" " ..... " 9	1077	1644
	" " ..... " 10	1255	1822
	" " ..... " 11	1217	1784
	Tunnel	1400	1967
	Base of Plane.....No. 12	779	1346
	Head of Plane.....No. 12	928	1495
	Hamlin	329	896
Empty track back to Port Griffith's.	Head of Plane.....No. 13	511	1078
	" " ..... " 14	640	1207
	" " ..... " 15	733	1300
	" " ..... " 16	830	1397
	" " ..... " 17	874	1441
	" " ..... " 18	955	1522
	" " ..... " 19	998	1565
	" " ..... " 20	952	1519
	" " ..... " 21	1040	1607
	" " ..... " 22	246	813
	Foot of Plane ..... " 22	64	631

CXIX. Montrose R. W.

Elevations on the Montrose Railway were furnished by Mr. James I. Blakslee, President of the Company.

The datum, or base of levels, is that of grade on the Lehigh Valley R. R. at Tunkhannock.

STATIONS.	Mean Tide.	Ocean Level.
Tunkhannock (*a*).....CXIV	614	617
Marcy.....	968	971
Lemon.....	1044	1047
Avery.....	982	985
Meshoppen Creek.....	936	939
Lynn	1035	1038
Springville.....	1260	1263
Tylersville.....	1403	1406
Dimock	1510	1513
Hunter's.....	1550	1553
Cool's.....	1550	1553
Allenville	1652	1655
Montrose.....	1659	1662

a Junction with Lehigh Valley R. R.

CXX. Barclay and Schrader R. R.

Elevations on the Barclay and Schrader R. R's were furnished by Mr. A. W. Stedman, Engineer of the Pa. & N. Y. R.R. & Coal Co., at Towanda, Pa., through the solicitation of Mr. James Macfarlane.

The datum is mean tide at Philadelphia.

STATIONS.	Mean Tide.	Ocean Level.	
Towanda (*a*).....CXIV	732	735	
Towanda (*b*).....	719	722	
Monroeton Junction (*c*)....CXXI	756	759	
Masontown (*d*).....	788	792	
Greenwood.....	817	820	
Lamoka.....	1036	1039	
Foot of Plane (*e*).....	1265	1268	
Head of Plane (*f*).....	1750	1753	
Schrader R. R.*			
R. R. Switch (*g*).....	1795	1798	
R. R. Switch (*h*).....	1782	1785	
Carbon Run (*i*).....	1923	1926	
Lowest Point (*j*).....	1970	1973	
Summit.....	2035	2038	

*This Railroad, four miles long, connects the Barclay R. R. with the Schrader Coal Mines.

a Switch at Upper Depot.
b Barclay Depot.
c With State Line and Erie R. R.
d Barclay R. R. Bridge rail.
e *Elevation estimated.*
f Rail in Plane-house.
g Upper Switch connecting with Barclay R. R.
h Lower Switch connecting with Barclay R. R.
i Rail under Breaker is 1923'.
j Lowest Point of Coal near Breaker.

CXXI. State Line and Erie R. R.

Levels on the State Line and Erie R. R. were copied from a profile in the office of the Company at Towanda, Bradford County, Pa. There were no stations, or names of towns, noted on the profile, the elevations being marked at mile posts, and therefore, the stations have been located from J. A. Anderson's R. R. map. The levels as shown in this list may not be entirely correct; but it is the only record which could be found.

The datum is Mean Tide at Philadelphia.

STATIONS.	Mean Tide.	Ocean Level.	
Monroeton Junction (*a*).....CXX	756	759	
Wilcox.....	1117	1120	
New Albany.....	1191	1194	
Miller's.....	1324	1327	
Bushore.....(?)	1587	1590	
Bernice.....	1852	1855	

a With Barclay R. R.

IV. DELAWARE SERIES.

CL. Philadelphia and Trenton R. R.

Levels on the Philadelphia and Trenton, and Belvidere Division of the Pennsylvania R. R. were furnished by Mr. F. B. Fiddler, Engineer in the office of the Company at Trenton, N. J. The levels were deduced from the original table of grades by Samuel H. Kneass, Engineer.

The datum of the Philadelphia and Trenton R. R. is mean tide at Philadelphia. The datum of the Belvidere Division of the Pennsylvania R. R. is water in canal at junction of feeder with Delaware and Raritan Canal near Trenton, which water level is four feet below the railroad track.

Philadelphia, Trenton and Belvidere Division, Pennsylvania R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Philadelphia.....			
Kensington (*a*).....	29	32	
Bridge over Frankford Creek....	24	27	
Frankford Station (*b*).....	29	32	
Bridesburg (*c*).....	29	32	
Tacony.....	31	34	
Bories.....	32	35	
Cornwell's.....	36	39	
Eddington (*d*).....	39	42	
Bristol (*e*).....	18	21	
Tullytown.....	17	20	
Penn Valley.....	18	21	
Morrisville (*f*).....	31	34	
Trenton Junction (*g*).....	60	63	
Washington's Crossing.....	64	67	
Prime Hope Saw Mills.....	CLI		
Lambertville.....	72	75	
Prallsville.....	83	86	
Bull's Island (*h*).....	94	97	
Warford's Rock.....	CLI		
Frenchtown.....	125	128	
Milford.....	137	140	
Holland.....	CLI		
Reigelsville.....	163	166	
Carpenterville.....	175	178	
Phillipsburg (*)).....CXIV	195	198	
Martin's Creek.....	231	234	
Belvidere.....	268	271	
Manunka Chunk.....	320	323	
Walker's Ferry Water Gap.....	CLI		

a Frankford Road Crossing.

b Middle of Church Street.

c Middle of Bridge Street.

d Dunk's Ferry Road.

e Middle of Market Street.

f N. E. side of Washington Street.

g The railroad track is four feet above the water in the canal.

h Elevation of railroad, head of Bull's Island, 97′. Low water in Delaware River 74′.

* Lehigh Valley R. R.

CLI. Delaware River Levels.

NOTE.—The following levels of ordinary low water in Delaware River above *mean tide at Philadelphia* (= 3.349 above mean ocean level) were obtained in the office of the Philadelphia and Trenton R. R. at Trenton, from Mr. F. B. Fiddler, C. E., deduced from the original grade tables by Mr. S. H. Kneass.

PLACES.	Mean Tide.	Ocean Level.
Trenton		
Washington's Crossing	20	23
Prime Hope Saw Mills	35	38
Lambertville	49	52
Bull's Island	71	74
Head of Bull's Island	74	77
Warford's Rock	91	94
Frenchtown	104	107
1.7 miles above " (*a*)	107.7	111
Milford	111	114
4 miles above " (*b*)	121.8	125
Holland	116	119
1½ miles below Reigelsville	124.2	127
Reigelsville	127	130
⅝ mile above "	130	133
1.6 mile above "	133.8	137
Carpenterville	137	140
2½ miles below Phillipsburg (*c*)	148.6	151
Phillipsburg	157	160
1¾ mile above "	165.2	168
2.7 miles above "	170.4	173
7.6 miles above "	192.8	196
2.84 miles above Martin's Cr. (*d*)	200.4	204
4.14 miles above "	210.9	214
Belvidere	232	235
Manunka Chunk	262	265
Walker's Ferry at Delaware Water Gap	298	301

CLII. Delaware Canal.

Elevations on the Delaware Canal were copied from a map made under the direction of the Lehigh Coal and Navigation Company, in 1826, by Isaac A. Chapman. The map is in possession of Mr. George Ruddle, Mauch Chunk. The datum is low tide Delaware River, 3.349 above Ocean Level.

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a Huntingdon County, N. J., 31.7 miles above Trenton.
b " " " not the Milford of Pike County, Pa.
c Opposite Easton, in New Jersey.
d Above Easton, in Pennsylvania.

POINTS ON LINE OF CANAL.	Low Tide. Feet.	Inches
Trenton Falls; head; 49 miles below the mouth of Lehigh River	9	8
Gould's Rift; head	16	8
Yardleyville	18	
Scudder's Rift; head	24	8
Taylor's Rift; head	33	6
Buck Tail Rift; head	36	5
Will's Falls; head	49	9
New Hope	50	
33 miles below Lehigh River	53	3
Green Banks Rift; head	58	9
Gallopen's; head	68	3
Bull's Falls; head	72	2
26 miles below Lehigh River	72	9
Cut Bite Rift; head	77	4
Tumbling Dam Falls; head	89	1
Marshal's Island Rapids; head	100	7
Man of War Rift; head	102	3
Stunt's Falls; head	107	2
Firman's Falls; head	110	11
Nockamixon Falls; head	117	6
Linn's Falls; head	124	10
11 miles below Lehigh River	126	10
10 miles below Lehigh River	127	3
Durham Falls; head	130	3
9 miles below Lehigh River	130	4
Greavelly Falls; head	133	3
Rocky Falls; head	136	1
Ground Hog Rift; head	138	1
Old Sow Rift; head	145	7
Clifford's Rift; head	150	10
Bixler's Rift; head (*a*)	160	5

a This point is about one-half mile below the mouth of Lehigh River.

CLIII. Philadelphia and Newtown R. R.

NOTE.—See Appendix.

CLIV. Flemington R. R.

Levels on the Flemington R. R. were copied from a list prepared by Mr. F. B. Fiddler, in the R. R. office, at Trenton, N. J.

The datum is mean tide Delaware River, = 3.349 above Ocean Level.

STATIONS.	Mean Tide.	Ocean Level.	
Flemington Junction (*a*).....CL	73	76	
Mount Airy	147	150	
Ringoes	248	251	
Summit (*b*)	255	258	
Copper Hill	159	162	
Flemington	183	186	

a Junction with Belvidere and Delaware R. R.

b N. E. of Ringoes.

NOTE.—Two other short lists in New Jersey are here appended, on account of their connections with the Delaware River lines. Other New Jersey Railway levels are published by Prof. Cook in his Annual Reports of the Geological Survey of that State.

Morris and Essex R. R.

The Morris and Essex R. R. levels were furnished by Mr. James Archbald, Chief Engineer, Del. L. & W. R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Phillipsburg.....CL	217	220	
Phalcony Creek.....	341	344	
Stewartsville.....	370	373	
Washington Depot.....	503	506	
Port Murray.....	585	588	

Belvidere and Newtown R. R.

NOTE.—The Belvidere and Newtown levels were copied from a list furnished by Mr. F. B. Fiddler, Trenton, N. J.

STATIONS.	Mean Tide.	Ocean Level.	
R. R. Junction (*a*).....CL	272	275	
Belvidere.....	283	286	
Sarepta.....	361	364	
Hope	478	481	
Howell P. O.....	562	565	
Summit	595	598	
Johnsburg.....	568	571	
Summit	628	631	
Newton.....	607	610	

a Junction with B. D. R. R.

CL V. Delaware, Lackawanna and Western R. R.

Elevations on the D. L. & W. R. R. were copied from a profile in the office of the Company at Scranton, by permission of the Assistant Engineer, Mr. Bryson.

The datum is mean tide, Delaware River, = 3.349 above Ocean Level.

STATIONS.	Above Tide.	Ocean Level.	Corrected.
Junction (Central R.R. of N. J)..			
Washington (Morris & Essex R.R.)			
Oxford Furnace.....			
Bridgeville.....			
Manunka Chunk.....CL			
Delaware Bridge.....	290	293	
Portland.....	288	291	
Delaware Water Gap.....	316	319	

STATIONS.	Above Tide.	Ocean Level.	Corrected.
Stroudsburg	400	403	
Sprague ville	487	490	
*Henryville	593	596	
*Oakland	1008	1011	
*Paradise	1518	1521	
Forks			
Tobyhanna (*a*)	1929	1932	
Gouldsboro			
Summit	1887	1890	
*Moscow	1555	1558	
*Dunning's	1397	1400	
Greenville	1182	1185	
Scranton.....CLVI, CXVIII	740	743	
Clark's Summit	1239	1242	
Abington	1055	1058	
Factoryville	917	920	
Tunnel	963	966	
Nicholson	766	769	
Hopbottom	890	893	
Foster			
Oakley's	942	945	
Montrose Station	1050	1053	
New Milford	1084	1087	
Great Bend	876	879	
State Line	860	863	
Corbettsville	852	855	
Conklin	849	852	
Binghamton.....CLXII	843	846	

a The highest point noted on the profile, 1970 feet above tide. This point is between Tobyhanna & Summit.

* Elevations at stations marked thus (*) were not marked on the profile; neither could it be exactly determined what was the vertical scale of the profile; but it was supposed to be 200 feet to the inch.

The following list is therefore added, some of its figures corresponding exactly with those above. It was obtained from a profile in the office of the Pennsylvania Canal Co., at Harrisburg, made under the direction of J. Dutton Steele, in 1851.

STATIONS.	Above Tide.	Ocean Level.	
White House	170	173	
Lebanon	274	277	
Clinton	326	329	
New Hampton Summit	505	508	
West End Switch	498	501	
Delaware Bridge	293	296	
Delaware Water Gap	314	317	
Stroudsburg	422	425	
Naglesville	1961	1964	
Greenville	1182	1185	
Scranton	739	742	

CLVI. Bloomsburg Division, D. L. & W. R. R.

Elevations of the Bloomsburg Division of the Delaware, Lackawanna and Western R. R. were copied from notes, in the possession of Mr. A. Bryson, Jr., Div. Engineer, at Scranton, Pa. This list contains all the levels that could be obtained of this road.

STATIONS.	Mean Tide.	Ocean Level.	
Scranton.....CLV	740	743	
Taylorville.....	683	686	
Lackawanna Junction.....	573	576	
Pittston.....	573	576	
West Pittston.....	580	583	
Wyoming.....	560	563	
Maltby.....	560	563	
Kingston.....	551	554	
Plymouth Junction.....	545	548	
Plymouth.....	539	542	
Avondale.....	534	537	
Nanticoke.....			
Hunlock's Creek.....			
Schickshinny.....			
Beach Haven.....			
Berwick.....			
Brier Creek.....			
Espey.....			
Bloomsburg.....			
Rupert.....			
Catawissa Bridge.....			
Danville.....			
Northumberland.....			
Sunbury.....			

CLVII. Lackawanna R. R.

Elevations on the Lackawanna R. R. between Carbondale and Scranton were furnished by Mr. A. H. Vaudling, Superintendent Delaware and Hudson Canal Co.'s R. R. at Providence, Luzerne County, Pa.

The datum is "Tide;" but whether high tide or mean tide is not known. Supposing it to be *mean* tide, 3.349 feet is added for Ocean Level.

STATIONS.	Above Tide.	Ocean Level.	
Carbondale (*a*).....CLX	1083	1086	
Jermyn.....	968	971	
Archbald.....	965	968	
Olyphant.....	807	810	
Providence (*b*).....	700	703	

a Coal Brooke Breaker in Carbondale. The *canal level* at Carbondale is given by J. D. Steele as 965; see Table CLVIII.

b Elevation at the Lackawanna.

CLVIII. Carbondale & Honesdale R. R.

Levels on the Carbondale and Honesdale Railroad are in accordance with a profile furnished by Mr. A. H. Vandling, Superintendent of the Delaware and Hudson Canal Company, office of coal department, at Providence Penna. According to the profile which is marked, "Profile B, New Road," the *loaded* track starts from Carbondale at a point marked 1012 feet above tide; and the *empty* track starts at a point marked Honesdale 1000 feet above tide. In J. D. Steele's list (CLVIII) Carbondale and Honesdale are both alike called 965 above tide, at the level of the canal.

	STATIONS.	Above Carbondale.	Above Tide.	
Loaded cars, eastward.	Carbondale, lower end.....	00	1012	
	Head of Plane 1.....	240	1252	
	Head of Plane 2.....	377	1389	
	Head of Plane 3.....	579	1591	
	Head of Plane 4.....	762	1774	
	Head of Plane 5 (*a*)	923	*1935	
	Head of Plane 6.....	906	1918	
	Head of Plane 7.....	572	1584	
	Foot of Plane 7 (*b*).....	440	1452	
Empty cars back.	Honesdale..... CLIX	00	1000	1003
	Head of Plane 1.....	180	1180	1183
	Head of Plane 2.....	178	1178	1181
	Head of Plane 3.....	290	1290	1293
	Head of Plane 4.....	424	1424	1427
	Head of Plane 5.....	502	1502	1505

CLIX. Honesdale Branch Erie Railway.

STATIONS.	Above Tide.	Ocean Level.	
Honesdale.....CLVIII	966		
White Mills.....	925		
Hawley	899		
Kimbles.....	849		
Millville	780		
Rowlands	700		
Lackawaxen	650		

CLX. Delaware and Hudson Canal.

This list is from J. Dutton Steele's profile of 1851, in Penna. Canal Co'.s office, at Harrisburg.

TOWNS.	Above Tide.	Ocean Level.	
Carbondale.....CLVII	965		
Honesdale.....	965		
Hawley.....	880		
Port Jarvis.....	455		
Port Clinton.....	455		

a Summit.
b From this point to Honesdale, a distance of 10 miles, there is a regular descent of 44 feet to the mile.

CLXI. Jefferson Branch, Erie Railway.

STATIONS.	Above Tide.	Ocean Level.	
Lanesboro Junction (*a*)....CLXII	982		
Ninevah Junction	981		
Brandts	1047		
Stevens Point	1078		
Webster's Mills	1297		
Starrucca	1424		
Thompson	1703		
Ararrat Summit	2023		
Herrick Centre	1803		
Uniondale	1693		
Forrest City	1481		
Carbondale	1079		

a With the Erie Railway at Lanesboro, in Susquehanna Co., Pa., about 190 miles from New York City. This road runs south to the Anthracite Coal field.

CLXII. Erie R. R. Line.

Levels on the Erie Railway were copied from profiles furnished by Mr. H. D. Blunden, Assistant Engineer. The profiles are complete, embracing the main line of road from Jersey City to Dunkirk, and all branches owned by the Erie Railway Company.

The datum is tide water at Jersey City. This, if *mean tide*, may be considered equivalent to Ocean Level.

Erie R. R.—Delaware Div.

STATIONS.	Above Tide.	Ocean Level.	
Port Jervis	440		
Pond Eddy	571		
Shoholo	648		
Lackawaxen....CLX	648		
Pine Grove	668		
Narrowsburg	714		
Nobodys	748		
Cohecton	748		
Callicoon	781		
Rock Run	787		
Hawkins	809		
Basket	830		
Bouchon	850		
Lordville	864		
Stockport	896		
Hancock	926		
Dickinsons	954		
Hales Eddy	974		
Deposit	1009		
Summit	1373		
Susquehanna....CLXI	914		

Erie R. R.—Susquehanna Div.

Great Bend	884		
Binghamton.....CLV	868		
Hooper	839		
Union	834		
Campville	830		
Owego	822		
Tioga	805		
Smithboro	799		
Waverly	836		
Chemung	820		
Wellsboro	831		
Elmira	863		
Corning.....CLXIV	942		
Painted Post	947		
Erwins	983		
Addison	993		
Rathboneville	1015		
Cameron Mills	1029		
Cameron	1056		
Santees	1067		
Adrian	1112		
Canesteo	1134		
Hornellsville	1161		

Erie R. R.—Western Div.

Tip Top Summit	1783		
Andover	1676		
Genessee	1511		
Scio	1458		
Philipsville	1390		
Belvidere	1384		
Friendship	1539		
Cuba Summit	1698		
Cuba	1542		
White House	1514		
Hindsdale	1501		
Olean	1438		
Allegheny	1422		
Vandalia	1415		
Carrollton.....CLXVI	1399		
Great Valley	1393		
Salamanca	1384		
Little Valley	1594		
Cattaraugus	1411		
Persia	1390		
Smith's Mills	1010		
Forestville	883		
Dunkirk (*a*)	600		

a The elevation given at Dunkirk by Lake Shore and Michigan Southern R. R., is 24.94 + 573. L. Erie = 597.94.

CLXIII. Erie R. R.—Buffalo Div.

STATIONS.	Above Tide.	Ocean Level.
Arkport	1199	
Burns	1203	
Caneseraga	1260	
Garwoods	1280	
Swains	1312	
Turnout	1319	
Nunda	1336	
Hunts	1339	
Portage	1314	
Castile	1401	
Gainesville	1407	
Warsaw	1326	
Dale	1178	
Linden	1181	
Attica	998	
Tonawanda	1003	
Summit	1086	
Griswold	1044	
Darien	1024	
Alden	868	
Town Line	742	
Lancaster	683	
Checktowga	661	
East Buffalo	611	
Buffalo	588	

CLXIV. Corning, Cowanesque & Antrim Railway.

The levels on Corning, Cowanesque and Antrim Railway, were furnished by Mr. A. H. Gorton, Supt. The levels on this road have been reduced to the datum of the New York and Erie Railway, by adding 26 feet to Mr. Gorton's figures.

STATIONS.	Tide.	Corrected Tide.
Corning.....CLXII	*918	†942
Ernin Centre	952	976
Lindley	973	997
Lawrenceville.....CLXV	982	1006
Nelson	1162	1186
Elkland	1118	1142
Lawrenceville.....CLXV	982	1006
Tioga Village	1028	1052
Holliday	1127	1151
Middleburg	1154	1178
Niles Valley	1168	1192
Wellsboro	1295	1319
Summit	1838	1862
Antrim Coal Mines	1648	1672

* Grade at Corning Junction according to Mr. Gorton.

† Grade at Corning Junction by profile of Erie Railway.

CLXV. Tioga R. R.

Levels on the Tioga R. R. were furnished by Mr. S. B. Elliott, Engineer of the T. R. R.

The datum is asserted to be that of the Erie R R. at Corning; in other words the following figures have been constructed on the basis of the Erie R. R. list, without reference to Mr. Gorton's intermediate station levels.

STATIONS.		Above Tide.	Ocean Level.
Lawrenceville	CLXIV	1006	
Somer's Lane		1018	
Mitchell's Creek.....		1022	
Old Station		1035	
Tioga.....		1042	
Mill Creek		1077	
Lamb's Creek.....		1111	
Mansfield.....		1140	
Canoe Camp.....		1163	
Covington.....		1208	
Blossburg.....		1348	
Morris Run (*a*).....		1678	
Arnot (*b*).....		1682	
Fall Brook (*c*).....		1842	

a, *b*, *c* Coal Mines in the Blossburg Basin.

CLXVI. Bradford Branch, Erie Railway.

STATIONS.	Above Tide.	Ocean Level.	
Carrollton Junction (*a*)....CLXII	1400		
Ernins Mills	1409		
Limestone.....	1415		
Babcock.....	1429		
Bradford	1464		
DeGolias	1510		
Big Shanty	1715		
Crawfords	2098		
Summit (*b*).....	2140		
Alton	2080		
Gilesville.....	2016		

a With the Erie R. R., 407 miles from New York. This road runs south to the coal fields of McKean Co., Pa.

b Highest point on the profile just south of Crawfords.

V. SUSQUEHANNA SERIES.

CC. Northern Central.

Levels on the N. C. R. R. were copied from an old lithographed profile in the office at Baltimore, Md.

Datum: Mean tide at Baltimore; equivalent to + Ocean level.

STATIONS.	Mean Tide.	Ocean Level.
Baltimore		
B. & P. R. R. Junction		
Mount Vernon	131	
Green Spring Junction (*a*) CCLV		
Timonium	381	
Cockeysville		
Sparks		
Monkton		
Parkton	420	
Freelands	596	
New Freedom	827	
Seitzland	611	
Glen Rock	551	
Hanover Junction (*b*)	422	
Smysers	389	
Glatfelter's	335	
Tunnel	299	
York (*c*) CCVI, CCVII	366	
Emigsville	376	
Mount Wolf	376	
Summit, No. 2	466	
Conewago Bridge	289	
York Haven	291	
Goldsboro	304	
Middletown Ferry	307	
Marsh Run	307	
New Cumberland	312	
Bridgeport (*d*) CCIX	355	
Marysville	350	
Dauphin (*e*) LXIII		
Clark's Ferry	361	
Halifax	378	
Liverpool		
Mohontongo		
Millersburg (*f*) CCXI	396	
Georgetown	417	
Trevorton Junction (*g*) LXIX	428	
Fisher's Ferry	433	
Selinsgrove	438	
Sunbury (*h*) CCXV	444	

a With Green Spring Branch N. C. R. R.

b With Hanover Branch, Han. & Gett. R. R.

c Junction with Peach Bottom R. R. and with York and Columbia R. R., and York & Gettysburg R. R.

d Opposite Harrisburg. Junction with Cumberland Valley R. R.

A list of levels of some of the above named points made by J. D. Steele, in 1851, was obtained in the office of the Penna. Canal Co., at Harrisburg, and is given for comparison, as follows:

STATIONS.	Mean Tide.	Ocean Tide.	
Mellvale	168		
Timonium	395		
Ashland	269		
Monckton	344		
Parkton	430		
Summit	860		
Glenrock	556		
Glatfelter's	472		
York	373		
Conewago Creek	285		
Bridgeport	343		
Dauphin	332		
Halifax	360		
Lykens V. R. R. Junction	380		
Millersburg	382		
Georgetown	417		
Sunbury.....CCXV	429		

CCI. Tide Water and Susquehanna Canal.

Levels on the T. W. & S. Canal, were copied from a profile in the office of the Schuylkill Navigation Company, at Reading, Pa., by permission of Mr. James F. Smith, Chief Engineer.

Datum, *low tide* at Havre de Grace. Information on the spot leads to the belief that the tide rises here 2½ feet.

Tide Water Canal.

STATIONS.	Above Low Tide.	Ocean Level.	
Level of Chesapeake Bay	0		
Lock No. 9, surface of water	10		
Lock No. 8, " "	16		
Lock No. 7, " "	26.5		
Lock No. 6, " "	37		
Lock No. 5, " "	47		
Lock No. 4, " "	57		
Lock No. 3, " "	67		
Lock No. 2, " "	77		

e Junction with Schuylkill and Susquehanna R. R.

f Junction with Lykens Valley Coal R. R. (Summit Branch R. R.)

g With Mahanoy and Shamokin Branch P. & Reading R. R.

h Junction 1. With Shamokin Division R. R. (CCXIV). 2. With Danville Hazleton and Wilkesbarre R. R. (CXVII). 3. With Philadelphia & Erie R. R. (CCXV). Note. The cars of the Northern Central run on the P. & E. R. R. to Williamsport, and then on the leased line from Williamsport to Canandaigua, once called the Williamsport and Elmira R. R., and now known as the northern extension of he Northern Central R. R.

Susquehanna Canal.

Lock No. 19, (next to No. 2, T. W. C)	85		
Lock No. 18, upper level	93		
Lock No. 17, " "	103		
Lock No. 16, " "	114		
Lock No. 15, " "	123		
Lock No. 24, " "	125		
Lock No. 23, " "	134		
Lock No. 22, " "	143		
Lock No. 22, " "	152		
Lock No. 20, " "	161		
Lock No. 9, " "	170		
Lock No. 8, " "	177.5		
Lock No. 7, " "	185		
Lock No. 6, " "	193		
Lock No. 5, " "	201		
Lock No. 4, " "	209		
Lock No. 3, " "	217		
Lock No. 2, " "	225		
Lock No. 1, " "	233		
Aqueduct across Cabin Branch Creek	233		
Grand Lock at Wrightsville, opposite Columbia	233		

CCII. Pennsylvania Canal, E. D.

Elevations on the Pennsylvania Canal, Eastern Division, were furnished by Mr. Thos. T. Wierman, Jr.

Datum is *mean tide*, Chesapeake Bay.

STATIONS.	Mean Tide.		
Columbia Dam, surface	221		
Canal Basin, (Columbia)	236		
Susquehanna River below Conewago Falls	244		
Susquehanna River above Conewago Falls	263		
Harrisburg Canal Basin (*a*)	312		
Clark's Ferry Dam	333		

a Surface of water in the large (Porter's) Basin at Harrisburg 320

Floor of vestibule of the State Capitol at Harrisburg 361

CCIII. Juniata Division Pennsylvania Canal.

Juniata River, Mouth :—			
Mitre Sill of Stop Lock at Junction CCIV	347		
Millerstown dam, surface	376		
Lewistown dam, "	442		
Canal at Lewistown "	450		
Anghwick dam, "	492		
Canal at Huntingdon "	586		
Huntingdon :			
Lower Mitre Sill of Lock No. 40	599		

CCIV. West Branch Division Pennsylvania Canal.

Juniata River, Mouth :—(*b*)			
Mitre Sill of Stop Lock at Junction.....CCIII	347		
Liverpool, water in River	368		
Liverpool, water in Canal	381		
Water in			
River below Shamokin dam ...	411		
Shamokin dam, at Sunbury....	419		
Canal at Northumberland..CCV	432		
Lewisburg dam (*c*).....	424		
Canal opposite Lewisburg.....	445		
Muncy dam	459		
Loyalsoch dam and Canal.....	502		
Canal at Williamsport	509		
Lock Haven dam.....	540		
Queens Run dam.....	546		
Bald Eagle dam.....	559		

b Surface of water of Pool of dam at Duncan's Island 332

c This dam has no connection with the Canal, and is therefore at a lower level.

CCV. Wyoming Division Pennsylvania Canal.

Northumberland; canal levelCCIV	432		
Bench Mark at Northumberland..	434		
Danville ; canal level	443		
Bloomsburg ; canal level.....	470		
Below Berwick ; canal level	480		
Shickshinny ; canal level.....	500		
Nanticoke dam	504		
Wilkesbarre ; canal level.....	534		
Water in river above Wilkesbarre	511		
Top of coping Plainsville Lock...	541		

CCVI. Peach Bottom R. R.

Levels of the Peach Bottom R. R. were copied from notes in the office at York.

Datum: Susquehanna River at Peach Bottom, on the assumption that the water in the river at Peach Bottom stood at 85.88 feet above tide.

According to the profile of the Frederick Division of the Pa. R. R., the elevation of York above tide at Baltimore, is 364.6 feet. This is the latest determination. Sixteen feet have therefore been substracted to make the second column.

This R. R. is a 3 foot or "Narrow Guage," and connects with the Northern Central R. R. at York.

STATIONS.	Assumed Datum.	Corrected Tide.	
Susquehanna River Water	(85.88)	(70)	
Peach Bottom (*a*)	92.27	76	
Bangor Summit	511.23	495	
Delta	435.37	419	
Bryansville.....	241.36	225	
Woodbine.....	294.21	278	
Bridgeton.....	304.89	289	
Bruce.....	331.50	315	
Muddy Creek	366.86	351	
High Rock	382.93	367	
Laurel.....	411.62	395	
Fenmore	434.64	418	
Brogueville.....	478.19	462	
Felton.....	536.46	520	
Windsor	598.8	583	
Springvale	734.4	718	
Red Lion.....	912.31	896	
Dallastown	657.00	641	
Ore Valley	570.32	554	
Enterprise.....	531.20	515	
Smalls Mills.....	433.75	418	
Springgarden	431.53	415	
York .....CC,, IV CCVII	381.24	365	

a There is a Peach Bottom R. R. in Lancaster Co., branching from the Philadelphia and Baltimore Central, at Oxford, (see table CCLII,) and intended to connect with this line of York Co. at Peach Bottom, on the Susquehanna River.

CCVII. Pennsylvania Railroad, Frederick Division.

Levels of the Frederick Division, Pa. R. R., were copied from a profile of the road, in the office of the Pa. R. R. at Philadelphia, by permission of Mr. W. H. Brown, Engineer for Maintenance of Way.

Datum: Mean tide at Baltimore.

STATIONS.	Mean Tide.	Ocean Level.	
York (*a*).....IV, CC	365		
Codorus Creek.....	357		
Graybills	426		
Bairs.....	452		
Spring Forge.....	455		
Menges Mill.....	455		
Iron Bridge.....	496		
Jacobs Mill	504		
R. R. Crossing (*b*).....	607		
Hanover.....	599		
Conewago Bridge	546		
Littlestown	619		
Bridge	623		

a Junction with Northern Central; with York Branch of Columbia R. R.; and with Peach Bottom.

b Hanover Junction and Gettysburg R. R. Crosses at grade.

STATIONS.	Mean Tide.	Ocean Level.	
State Line.....	540		
Piney Creek.....	505		
Galts.....	486		
Taneytown	493		
R. R. Crossing (*c*).....CCLV	426		
Ladiesburg.....	464		
New Midway.....	458		
Woodsborough	400		
Georgetown	290		
Ritters.....	301		
Harmony Grove.....	310		
Frederick.....	280 (?)		
B. & O. Junction (*d*).....CCLVI	375		

c Western Maryland R. R., but *not at grade.*
d Connection with Baltimore and Ohio R. R.

CCVIII. Cumberland Valley R. R.

Levels on the Cumberland Valley R. R., were furnished by Mr. J. B. Dougherty, Engineer of the road at Chambersburg.

Datum: Originally a point on the Penna. R. R. at Harrisburg, foot of Market street, 315 feet above high water at Philadelphia.

STATIONS.	High Tide.	Ocean Level.	
Harrisburg (*a*).....I, CC	315	322	
Susq. Bridge, (west end) (*b*).....	350	357	
Shirmanstown			
Mechanicsburg	429	436	
Dillsburg Junction (*c*).....CCIX	420	427	
Kingston			
Middlesex.....			
South Mountain Junction (*d*)....	451	458	
Carlisle	470	477	
Greason's.....			
Newville	526	533	
Oakville			
Shippensburg	647	654	
Summit (*e*)	776	783	
Scotland			
Mount Alto Junction (*f*).....	707	714	
Chambersburg.....	611	618	
Marion			
South Pennsylvania Junction (*g*)	625	632	
Greencastle.....	578	585	
State Line.....			
Hagerstown	565	572	
Falling Waters.....			
Potomac Bridge.....	369	376	
Beddington.....			
Martinsburg (*h*) CCLVI	457	634	

a Junction with Penna. R. R., and with Northern Central R. R.
b Bridgeport. *c* Dillsburg Junction. *d* South Mountain R. R. Junction.
e Mount Alto R. R. Junction. *f* Southern Penna. R. R. Junction.
g Junction with Baltimore and Ohio R. R.

CCIX. Mechanicsburg and Dillsburg R. R.

Levels on the Mechanicsburg and Dillsburg R. R. were copied from notes in possession of Mr. J. B. Dougherty, Assistant Engineer on the Cumberland Valley R. R., at Chambersburg, Pa.

Datum: That of the Pa. R. R., high tide at Philada.

STATIONS.	High Tide.	Ocean Level.	
Mechanicsburg Junc. (*a*) CCVIII	420	427	
Dillsburg.....	536	542	

a With Cumberland Valley R. R. at Mechanicsburg, 8.5 miles west of Harrisburg.

CCIX bis. South Mountain R. R.

No levels of this road could be obtained. It runs south from Carlisle by Papertown, to Pinegrove Furnace, on Mountain Creek in the South Mountains.

STATIONS.			
Carlisle Junction (*a*) CCVIII			
Bonny Brook			
Craigh Head's.....			
Mount Holly Springs.....			
Upper (Paper) Mill.....			
Hunter's Run.....			
Henry Clay			
Laurel			
Pinegrove (Furnace).....			

CCX. Mount Alto R. R.

Levels on the Mount Alto R. R, were furnished by Mr. George B. Wiestling, Engineer and Superintendent.

Datum is "Elevation of Rail at foot of Market street, Harrisburg, 315.2 above high tide in Schuylkill River at Philadelphia."

This road runs to Mount Alto Furnace at the west foot of the South Mountain.

STATIONS.	High Tide.	Ocean Level.	
C. V. R. R. Junction (*a*).....	705	712	
Summit (*b*)	732	739	
Brookside (*c*)	700	707	
Woodstock (*d*).....	708	715	
Chambersburg Turnpike (*e*)	740	747	
Reno Ore Bank	875	882	
Mount Alto (*f*)	961	968	

a Junction with Cumberland Valley R. R., near Chambersburg.
b Between C. V. R. R. and Conochocheague Creek.
c At crossing of Creek.
d At crossing of Creek.
e Chambersburg and Gettysburg Turnpike,
f Near the Furnace.

CCX bis. Southern Pennsylvania R. R.

No levels could be obtained.

STATIONS.		Ocean Level.	
C. V. R. R. Junction (*a*) CCVIII			
Williamson			
Lehmaster's			
Mercersburg Junction			
Loudon			
Richmond			
Mercersburg terminus			

* One mile south of Marion, and seven miles south of Chambersburg.

CCXI. Summit Branch R. R.

Levels of the Summit Branch R. R., were furnished by Mr. W. E. Ray, Supt. of the R. R., and cannot be relied upon as being entirely correct; but it is the only record which could be found of the road.

This road is called also the Lyken's Valley R. R.

Datum: Mean tide at Baltimore.

STATIONS.	Mean Tide.	Ocean Level.	
Millersburg (*a*)	395		
Elizabethville			
Cross Road	• 660		
Lykenstown	675		
Wiconisco			
Big Lick Colliery			
Williamstown (*b*)	1125		

a On the Susquehanna River, east side; junction with Northern Central Railroad.

b Summit Branch Colliery. Connection broken for several miles with the Railroad from Brookside, past Good Spring, to Tremont and Pottsville.

CCXII. Selinsgrove and N. B. R. R.

Elevations on the line of the Selinsgrove and North Branch R. R. and of the Mifflintown Branch, of the same, were copied from notes in possession of Mr. W. A. Meeker, at Selinsgrove, Pa.

Datum assumed at a point on the D. L. & W. R. R. at Northumberland.

The second column gives the correlative heights above mean tide (Ocean level?) at Baltimore.

NOTE. This R. R. has never been built. Only the preliminary line levels at the points named are given in the following table.

The line starts in Northumberland at the terminus of the Bloomsburg Division of the Delaware, Lackawanna & Western R. R., crosses the mouth of the West Branch Susquehanna, and keeps down the right bank of the Susquehanna River, to the mouth of the Juniata River (Table CCXII).

The other branch of the line strikes across country from Selinsgrove to the Juniata River at Mifflintown (Table CCXIII).

STATIONS.	Assumed Elevation.	Mean Tide.	Ocean Level.
Northumberland (*a*)..CLVCCXV	100	439	
River Road (*b*)	86.4	426	
Keensville	84.9	424	
Selinsgrove (*c*)	88.7	428	
Burns dwelling house	67.9	407	
Pa. Canal (*d*)	70.6	410	
B. M., No. 16 (*e*)	74.7	414	
Port Trevorton R. R. Track	75.9	415	
Herrold's Saw Mill	63.3	403	
B. M., No. 18 (*f*)	72.6	402	
Wentzels Station	66.3	406	
McKee's Half Falls	63.1	402	
Rines Store	60.2	400	
B. M., No. 21 (*g*)	60.6	400	
Mahontonga Creek (*h*)	38.2	378	
B. M., No. 23 (*i*)	61.5	401	
B. M., No. 24 (*j*)	54.9	385	
B. M., No. 25 (*k*)	50.9	390	
Liverpool (*l*)	57.3	397	
Blattenberger's Mill	34.8	374	
Blattenberger's Creek (*m*)	16.4	356	
B. M., No. 27 (*n*)	31.4	371	
Montgomery's Creek (*o*)	14.5	354	
Girty's Notch Hotel	26.2	366	
B. M., No. 28 (*p*)	19.1	358	
New Buffalo (*q*)	24.6	364	
Buffalo Creek (*r*)	8.5	348	
B. M., No. 31 (*s*)	18	357	
Pittsburg Turnpike Crossing	15.2	355	
B. M., No. 33 (*t*)	—1.8	338	
Juniata River	–11.6	328	
Juniata Canal (*u*)	18.4	358	
Pa. R. R. (*v*)	23.5	363	
B. M., No. 34 (*w*)..I	19.6	359	

a Intersection with D. L. & W. R. R., at Northumberland.
b Opposite Northumberland.
c Centre of Pine Street.
d Top of mason work abutment of aqueduct, 2½ miles below Selinsgrove, crossing Penns Creek.
e Spike driven in telegraph pole, just above Port Trevorton.
f Below Port Trevorton, near two dwelling houses, on root of apple tree, 300′ from canal.
g 1500′ south of Benneville Kramer's house, on root of wild cherry tree.
h Surface of water, ordinary stage.
i 900′ north of Hoover's hotel, on chestnut tree.
j 2000′ south of "Dry Saw Mill" Hotel, piece of horse shoe, driven in telegraph pole.
k 500′ south of McCormick's barn, on root of elm tree.
l Centre of Market street.
m Surface of water.
n 900′ north of stone hotel, on root of black walnut tree.

CCXIII. Mifflintown Branch S. & N. Br. R. R.

NOTE. See last table CCXII.

STATIONS.	Assumed Elevation.	Mean Tide.	Ocean Level.
B. M., No. 1 (*a*).....CCXII	101.2	441	
Kautz P. O. (*b*)	95.5	435	
Millers Mill.....	134.4	474	
Freeburg.....	157.2	497	
Apple's Brick House	205.8	545	
Road (*c*).....	263	602	
Cross Creek	286.5	626	
B. M., No. 13 (*d*).....	375	714	
Shelly's Saw Mill (*e*).....	451.4	791	
Shelly's Summit.....	453.2	793	
Richfield	412.6	752	
B. M., No. 14 (*f*).....	408.7	748	
Cherryhill School House (*g*)	366.8	706	
Evansdale Summit.....	399	738	
Haldeman's Store (*h*).....	377.4	717	
Bunkertown Church (*i*)	350.3	690	
Bunkertown	354.3	694	
Little Lost Creek (*j*).....	355.4	695	
McAlistersville.....	308.6	648	
Leonard s Barn.....	262.9	602	
Wilson's Mill.....	227.2	566	
Wilson's Store.....	219.5	559	
Main Road (*k*).....	224	563	
Banks Summit	270.6	610	
Happy Hollow School House (*l*)..	160.5	500	
Daniel Seiber's (*m*).....	137.3	477	
Terminus of Line (*n*).....I	109.2	449	

a Top of mile post No. 7, S. & L. R. R.
b Waters edge, ordinary low water, Middle Creek.
c Leading from Middleburg to Tremont.
d 1300′ west of Brick School House, root of white oak tree.
e Waters edge, head of Shelly's saw mill pond.
f Near rivulet.
g Public road crossing.
h Public road from Evansburg to Foutz Valley, opposite Haldeman's store.
i In public road, near Bunkertown Church.
j Surface of water.
k In main road, from McAlistersville to Mifflintown, one mile west of Oakland mills.
l Surface of water, creek or run, west of Happy Hollow school house.
m Surface of water in creek, at D. Seibers.
n Mifflintown, on large peg, with nail driven near corner of stable, at fence post.

o Surface of water.
p Point of rocks, foot of Girty's Mountain, spike driven in telegraph pole.
q Water in mill race.
r Surface of water.
s 700′ south of J. Steel's dwelling house, on root of black walnut tree.
t 600′ south of Pittsburgh turnpike crossing, on root of hickory tree, on river bank.
u On towing path, Juniata Canal.
v On cross tie, Pa. R. R., near Duncannon.
w On top of locust stump, at edge of embankment of Pa. R. R.

CCXIV. Shamokin Branch N. C. R. R.

The elevations on Shamokin Branch of the Northern Central R. R., were furnished by Mr. A. B. Starr, Assistant Engineer P. & E. R. R.
Datum: Mean tide, Baltimore.

STATIONS.	Above Tide.	Ocean Level.	
Sunbury Junction (*a*).....CC	442		
Snydertown.....	497		
Shamokin.....	738		
Lancaster Branch (*b*)	831		
Mount Carmel.....	1054		
End of Road..... ...	1090		

a Junction with N. C. R. W., at Sunbury.
b Junction with Lancaster Branch.

CCXV. Philadelphia and Erie R. R.

The levels on the Philadelphia and Erie R. R. were copied from the notes in the office of the Company at Williamsport, Pa., by permission of Mr. A. B. Starr, Assistant Engineer. These levels were made subsequent to 1862. It is intended to re-level the road in 1876, for no reliance is placed on the levels in this Table by the Engineers of the road.
Datum: Mean Tide at Baltimore.

STATIONS.	Mean Tide.	Corrected Levels.	
Sunbury (*a*).....CC	428.30		
D.H. & W.R.R. Junc. (*b*).CXVII	436.10		
Northumberland (*c*).....CLV	439.30		
Montandon (*d*).....XIII	446.60		
Catawissa R.R. Crossing (*e*)..LXV	454.50		
Milton.....	458.30		
Watsontown.....	465.62		
Dewart.....	470.40		
Catawissa R.R. Crossing (*f*) LXV	473.82		
Montgomery.....	474.10		
Muncy.....	502.75		
Catawissa R.R. Crossing (*g*)..LXV	514.42		
Williamsport.....	510.43		
W. & E. (N. C.) Railroad Junction (*h*).....CCXVII	516.02		
Newberry.....	513.20		
Linden.....	517.21		

a Junction of Shamokin Branch of the Northern Central R. R.
b Junction Danville, Hazleton and Wilkesbarre R. R.
c Junction of Delaware, L. & W. R. R.
d Junction of Lewisburg, Centre & Spruce Creek R. R.
e Crossing of Catawissa R. R. near Milton.
f Crossing Catawissa R. R. near Montgomery.
g Crossing Catawissa R. R. below Williamsport.
h Junction with Northern Central R. W. near Williamsport.

STATIONS.	Mean Tide.	Corrected Levels.	
Susquehanna	516.60		
Jersey Shore	*577.07		
Pine	554.11		
Wayne	554.34		
Lock Haven (*i*) XV	†538.91		
Queen's Run	565.05		
Farrandsville	564.63		
Ferney	576.44		
Glen Union	587		
Whetham	600.80		
Ritchie	614.34		
Hyner	626.30		
North Point	641.02		
Renova	653.90		
Westport	672.64		
Cook's Run	691.43		
Keating	700.90		
Wistar	720.72		
Round Island	736.81		
Grove	754.40		
Sinnemahoning	775.71		
Bennett's Br. Extension (*j*) CCCII	795		
Driftwood	797.75		
Huntley	842.93		
Sterling	896.38		
Cameron	943.73		
B. N. Y. & P. R.R. (*k*) CCXVIX	1003.09	(1024)	
Emporium	1014.99		
West Creek	1091.75		
Beechwood	1225.66		
Rathbon	1299.18		
Hemlock	1446.05		
West Creek Summit	1677.64		
St. Mary's	1649.50		
Scahonda	1503.90		
Daguschahonda (*l*)	1461.95		
Shawmut (*m*)	1408.56		
Ridgway	1375.73		
Johnsonburg	1423.52		
Wllmarth	1428.80		
Wilcox	1508.52		
Dahoga	1586.75		
Clarion Summit	2007.90		
Kane	2002.83		
Wetmore	1792.63		
Ludlow	1591.55		
Roy Stone	1403.75		

* Probably 557.07. † 558.91 ? See next Table below. See also the 555 of Table XV.

i Junction with Bald Eagle Valley R. R.

j Junction with the Bennett's Branch Extension of Allegheny Valley R. R.

k Junction with the Buffalo, New York & Philadelphia R. R.

l Here the Daguchahonda R. R. joins. No levels got.

m Shawmut R. R. No levels got.

STATIONS.	Mean Tide.	Corrected Levels.	
Sheffield	1325.70		
Tiona	1348.03		
Clarenden	1385.46		
Stoneham	1335.93		
Warren.....CCCVI	1182.60		
Oil Creek & A. V. R. R. Crossing.....CCCIV	1158.80		
Irvineton	1156.60		
Youngsville	1199.85		
Pittsfield	1233.31		
Garland	1297.47		
Spring Creek	1383.85		
Columbus	1389.18		
B.C.&P.R.R. Crossing (*l*) CCCIX	1429.20		
Corry	1419.58		
A.&G.W.R.R. Crossing (*m*) CCC	1415.92	(1439)‡	
Lovell's	1362.90		
Concord	1373.80		
Union	1258.63		
Lebeuff	1207.20		
Waterford	1181.72		
Jackson's	1218.70		
Langdon's	1123.52		
Belle Valley	995.96		
L. S. & M. S. Railroad Crossing (*n*).....CCCLXXXIII	675.64		
Erie Depot.....CCCLXXXIV	(573)		
Lake Erie, Water	(565)	(573)‖	

l Crossing of the Buffalo, Corry and Pittsburgh R. R.
m Crossing of the Atlantic & Great Western R. R.
n Junction with the Lake Shore and Michigan Central at Erie.
‡ Level by the N. Y. & E. R. R.
‖ Accepted level of Lake Erie.

NOTE.—In the following Table some levels according to a profile made by John F. Burgin, Civil and Topographical Engineer, in 1862, are compared with levels of the same points found in Table CCXV above.
Column 1 shows Mr. Burgin's figures.
Column 2 shows the office figures.

STATIONS.	Above Tide.	Above Tide.	Difference.
Sunbury	423	428	+ 5
Milton	451	458	+ 7
Williamsport	506	510	+ 4
Lock Haven (*a*)	552	539	+ 7
De Crano	716		
2d Fork Sinnamahoning	787	798 ?	+11
Emporium	1011	1015	+ 4
Foot of Maximum Grade	1330		

a The 539 must be an error for 559.

STATIONS.	Above Tide.	Above Tide.	Difference.
West Creek Summit	1682	1678	— 4
St. Mary's (*b*)	1628	1649	+21
Foot of Maximum Grade	1518		
Ridgway (*c*)	1387	1376	— 9
Johnsonburg	1429	1424	— 5
Wilcox	1501	1509	+ 8
Foot of Maximum Grade	1525		
Clarion Summit	2006		
Head of Two Mile Run	1914		
Foot of Maximum Grade	1456		
Sheffield	1324	1326	+ 2
Dutchman's Summit	1393		
Warren	1189	1183	— 6
Irvine	1162	1157	— 5
Youngsville	1203	1200	— 3
Pittsfield	1236	1233	— 3
Garland	1298	1297	— 1
Spring Creek Station	1381	1384	+ 3
Columbus	1388	1389	+ 1
Corry	1416	1420	+ 4
Logan's Summit	1429		
Lovell's	1363	1363	0
Concord	1372	1374	+ 2
Union	1259	1259	0
Le Boeuf	1205	1207	+ 2
Waterford	1181	1182	+ 1
Jackson	1218	1219	+ 1
Langdon's	1123	1124	+ 1
Belle Valley	994	996	+ 2
Erie Depot	573		
Lake Erie Surface (*d*)	565		

b Difference of 21 feet probably to be accounted for on the supposition that two different points are indicated, the gradients here being very steep.

c Head of the Clarion River, at the forks.

d The level of Lake Erie water was fixed by J. T. Gardner's Tables (U. S. Geol. and Geographical Survey of Colorado, for 1873, p. 635) "mean of observations from 1844 to 1857, 573.08;" adopted result at Cleveland, dependent upon repeated Erie Canal Levels and U. S. Coast Survey work.

CCXVI. Muncy Creek R. R.

The levels on the Muncy Creek R. R. were furnished by Mr. B. Morris Ellis, Treasurer.

Datum: Catawissa; (Reading) R. R. Mid tide at Philadelphia. Add 3 feet, for Ocean Level.

This R. R. line runs northeast, up Muncy creek to the top of the Allegheny or Great North Mountain table land of Sullivan County.

STATIONS.	Mean Tide.	Corrected Tide.	
Hall's Station (*a*) LXV	410	510	
*Hughesville (*b*).....	483	583	
Picture Rock.....	551	651	
Tivola.....	591	691	
Muncy Bottoms.....	675	775	
Sonestown.....	829	929	
McNeal's Summit (*c*).....	1676	1776	

a On Catawissa R. R. east bank of River.

b Mr. B. Morris Ellis, says, "This station is 80 feet higher than the Muncy Station (west side of river) on P. & E. R. R." called in Table CCXV, 502.75, and therefore, Hughesville is 582.75. Accordingly 100′ is added to Mr. Ellis' 483, and therefore to all other figures in the first column to make the second.

c This is the dividing ridge, between the Loyalsock and Muncy Creeks, which head within one-fourth mile of each other. It is known as McNeal's Summit, an engineer of that name having established a "bench" at this point many years since. It is two miles south of the town of Laporte (B. Morris Ellis).

Elevations of points in Sullivan County, Pa., furnished by Mr. B. Morris Ellis, of Hughesville, Pa.

In Cully township, in front of the hotel, at Long Pond, it is 2235′ above tide.

On the turnpike, one mile west of Long Pond, 2285′, the highest *known* point in Sullivan County.

At Lewis Lake, or Eagles Meare, it is 1726′.

CCXVII. Williamsport and Elmira R. R.

(NOW NORTHERN CENTRAL.)

Levels on this Northern Division of the Northern Central R. R. from Williamsport to Canandaigua, were copied from a profile in the office of the Company at Elmira. This road runs north up Lycoming creek.

Datum: Mean tide at Baltimore, Md.

STATIONS.	Mean Tide.	Ocean Level.	
Williamsport (*a*).....CCXV	540		
Cogan Valley.....			
Crescent.....			
Trout Run.....			
Bodine's.....			
Ralston.....	860		
Roaring Branch.....			
Carpenter's.....	1200		
Canton.....	1250		
Minnequa.....	1230		
Alba.....			
West Granville.....			
Granville Summit.....	1393		

a Junction with Philadelphia and Erie R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Troy	1100		
Columbia Cross Roads			
Snedeker's			
Gillett's			
New York State Line			
Elmira (*b*).....CLXII	865		
Horse Heads			
Pine Valley			
Mill Port			
Croton			
Havana	400		
Watkin's			
Rock Stream			
Starkey			
Himrod's			
Milo			
Pennyan			
Benton			
Hall's			
Stanley (*c*)			
Hopewell			
Canandaigua (*d*)	1070		

b Crosses New York and Erie R. R.
c Junction with Ontario and Southern R. R.
d Connects with New York Central and H. R. R. and Canandaigua and Tonawanda R. R.

CCXVIII. Jersey Shore, Pine Creek, and Buffalo R. R.

Levels on the J. S., P. Cr., and Buffalo R. R. were furnished by Mr. John S. Ross, Auditor. Datum: "Atlantic Ocean." This road is not yet built.

STATIONS.	Ocean Level.		
Williamsport, City limit (*a*) CCXV	502		
Linden (Surface of Canal)	501		
Larry's Creek (on Plank Road)	514		
Jersey Shore (Main Street)	521		
Pine Creek Crossing (Lentz)	532		
" " (Ramsey's Bend)	558		
Waterville (Surface Little Pine Cr)	587		
Jersey Mills	626		
Campbelltown	673		
Pine Cr. Crossing (near Slate Run)	709		
" " " Cedar "	760		
Babb's Creek Road	833		
Pine Cr. Crossing (ab. Marsh Cr.)	1106		
Gaines' (Water, Pine Creek)	1219		
Kilbourne's (Water, Pine Creek)	1274		
Grade at Summit of Tunnel	2202		
Coudersport	1634		
Roulette	1510		
Port Allegheny (*b*).....CCXIX	1454		

a The Canal level at Williamsport, however is 509 according to Table CCIII.
b On Buffalo, N. Y. & Phila. R. R.—The difference between the Tables 1479—1454 = 25′ is unexplained.

CCXIX. Buffalo, New York and Philadelphia R. R.

Elevations on the B. N. Y. and P. R. R. were furnished by Mr. Geo. S. Gatchell, Engineer, who writes: "Calling Lake Erie 573′ above tide, *our* elevation at the crossing of the Erie Railway, at Olean, is 1435. Erie (R. R. levels) 1438, difference 3′. At Buffalo our elevation is 11′ above what we took to be surface of water in Lake Erie, but I do not think it is exactly right. We assumed surface of water in Lake Erie from surface of water in Buffalo Creek, about 3 miles from the Lake. Lake Erie, 573′; our depot, 11′ = 584; Erie Railway (levels) 588; difference 4′. You see the difference at Olean & Buffalo is very near the same. The Erie Railway here (at Olean), is on about the same elevation as our track."

STATIONS.	+Lake Erie	Above Tide	Erie R. R. Correction.	
Emporium (*a*).....CCXV	448	1021	1024	
Shippen.....	630	1203	1206	
Keating (Summit).....	1305	1878	1881	
Liberty.....	1070	1643	1646	
Port Allegheny	906	1479	1482	
Larabee's.....	905	1478	1481	
Eldred.....	867	1440	1443	
State Line.....	867	1440	1443	
Portville.....	866	1439	1442	
Olean (*b*).....CLXII	862	1435	1438	
Hindsdale.....	880	1453	1456	
Ischua.....	965	1538	1541	
Franklinville.....	1017	1590	1593	
Machias	1080	1653	1656	
Yorkshire.....	882	1455	1458	
Arcade.....	881	1454	1457	
Protection.....	807	1380	1383	
Holland.....	600	1173	1176	
South Wales.....	414	987	991	
Aurora.....	348	921	925	
Jamieson.....	317	890	894	
Elma.....	250	823	827	
Spring Brook.....	180	753	757	
Ebenezer.....	63	636	640	
Buffalo (*c*).....	11	584	588*	

a On the Philadelphia and Erie R. R. where the unreliable list of the P. & E. R. R. makes the elevation 1003.09.

b Crosses New York & Erie R. R.

c Uses the same depot with the N. Y. & E. R. R., Lake Shore & M. S. R. R.

———. *Daguschahonda R. R.*

CCXX. McKean and Buffalo R. R.

Elevations on the McKean and Buffalo R. R. were furnished by Mr. S. V. Godden, Superintendent.

Datum: Lake Erie. To which must be added 573′ to reduce to Ocean Level.

The first column gives heights above an originally assumed Lake level. The second column corrects these heights for true Lake level.

STATIONS.	Above Lake Erie.	Above Lake Erie.	Above Tide.	
Buff. N. Y. & P. R. R. (*a*) CCXIX	873.00	896.50	1469	
Larabee's	871.50	895	1468	
Frisbee	860.50	884	1457	
Farmer's Valley	871.50	895	1468	
Smethport	889.06	913	1486	
Crosby	936.30	960	1533	
Colegrove	938.80	962.30	1535	
Hamlin	953.00	976.50	1549	
Wernwag	1256.50	1280	1753	
Clermont (*b*)	1469.50	1493	2066	

a Junction with the Buffalo, New York and Philadelphia R. R. near Larabee's Station, on the Upper Alleghany River. *b* Bishop's Summit.

VI. SOUTHERN SERIES.

CCL. West Chester and Philadelphia R. R.

The levels of the West Chester and Philadelphia R. R., were copied from the profile, by permission of Mr. Thos. H. Hall, Treasurer of the Company.

Datum: Ordinary *low* water at Philadelphia. This is about the same as Ocean Level.

STATIONS.	Above Tide.	Ocean Level.	
Philad'a Depot, 31st & Chestnut st	14	14	
Woodland Street	57	57	
Angora	74.5	74.5	
Fernwood	90	90	
Darby Road	103	103	
Kelleyville	102	102	
Clifton	109	109	
Springhill	128	128	
Morton	121.5	121.5	
Swarthmore	125	125	
Wallingford	168	168	
Manchester	211.5	211.5	
Media	210	210	
Greenwood	218	218	
Glen Riddle	160	160	
Lenni	136	136	
West Chester Junction (*a*) CCLII	133	133	
Darlington	143	143	
Glen Mill	199	199	
Cheney	240	240	
Street Road	252	252	
Hemphill	318	318	
West Chester	406	406	

a With Philadelphia and Baltimore Central R. R.

CCLI. West Chester R. R.

Elevations of points on the West Chester Railroad, were copied from a profile made in 1831, in possession of Mr. Thos H. Hall, Treasurer, at the office of the Company, in Philadelphia. There is no location of the present stations on the profile, therefore the elevations in the following list, are given at the points where marked on the profile.

Datum: "Tide;" but a correction of 21 was needful; see note *b*; add 7 feet for Ocean level below P. R. R. datum.

STATIONS.	"Tide."	Corrected Tide.	Ocean Level.
West Chester			
Liberty Grove (*a*)	475.6	455	462
Goshen Street	474.6	454	461
Jones Hill	540	519	526
Ship Road	471	550	557
Steamboat Road	599.50	579	586
Summit	607.33	587	594
Malvern Junction P. R. R. (*b*)	560	539	546

a The starting point of the road in the *eastern* part of the town of West Chester.

b Junction with Pennsylvania R. R. at Malvern Station. The elevation of the Pa. R. R. at this point is + 539.258. The levels on West Chester Railroad have been reduced to correspond with Pa. R. R.

CCLII. Philadelphia and Baltimore Central R. R.

Levels on the Philadelphia and Baltimore Central Railroad, were copied from a profile furnished by Mr. H. Wood, Gen'l Supt.

Datum is said to be *mid tide* at Philadelphia = about Ocean level.

STATIONS.	Above Tide.	Ocean Level.	
Lamokin Junction			CCLIII
Rockdale			
Lenni			
West Chester Junction (*a*)	133	133	CCLI
Chester Heights	234	234	
Patterson			
Woodland	212	212	
Concord	237	237	
Brandywine Summit	273	273	
Chadd's Ford	129	129	
Fairville	255	255	
Rosedale	312	312	
Kennett Square	260	260	
Toughkennamon	283	283	
Avondale	227	227	
West Grove	444	444	
Penn Station	506	506	
Elk View			
Lincoln University			
Oxford (*b*)			
Rising Sun			
Rowlandville			
Columbia & P. D. Junc. (*c*)			CCLIV

a With West Chester and Philada. R. R. *b* With Peach Bottom R. R.
c On the Susquehanna River above Port Deposit.

** *Peach Bottom R. R.*

STATIONS.			
Oxford Junction CCLII			
Hopewell			
Tweeddale			
Spruce Grove			
White Rock			
Kings Bridge			
Fairmount			
Fulton House.....			

** See CCVI.—Levels of this road wanting.

CCLIII. Philadelphia, Wilmington and Baltimore R. R.

Levels of the P. W. & B. R. R. were copied from the profile in the office of the Company at Philadelphia. Assumed level 94 feet too high.
Datum: Ordinary *low* water at Philadelphia = Ocean level.

STATIONS.	Profile.	Corrected Tide.	
Philadelphia.....			
Southwark	101.40	7.40	
Third Street	120.55	26.55	
Sixth Street.....	126.78	32.78	
Seventh Street	127.58	33.58	
Tenth Street.....	126.26	32.26	
Twelfth Street.	120.59	26.59	
Eighteenth Street	129.66	35.66	
Newport Street.....	137.53	43.53	
Greys Ferry Bridge.....	130.59	36.59	
Lazaretto	115.89	21.89	
Paschall			
Darby Street			
Sharon Hill			
Ridley Park.			
Chester Bridge (*a*)	118.33	24.33	
Lamokin Junc (*b*).....CCLII			
Thurlow	128.24	34.24	
Linwood.....	124.88	30.88	
Claymont.....	123.50	29.50	
Holly Oak	103.50	9.50	
Bellevue	108.07	14.07	
Wilmington LVI	101.11	7.11	
Delaware R. R. Junction			
Newport.....			
Staunton			

a Near Chester Station.
b Philadelphia and Baltimore Central R. R.

STATIONS.	Profile.	Assumed Elevation.	Corrected Tide.	
Newark	200.13	94	106.13	106
Iron Hill	216.70	94	122.70	123
Elkton	122.25	94	28.25	28
North East	137.75	94	43.75	44
Charlestown				
Perryville (*c*) CCLIV	115.48	94	21.48	21
Susquehanna (*d*)	110.34	94	16.34	16
Havre de Grace	110.12	94	16.12	16
Aberdeen	169.80	94	75.80	76
Perrymansville	136.39	94	42.39	42
Edgewood				
Magnolia				
Gunpowder Bridge	103.78	94	9.78	10
Chase's	114.40	94	20.40	20
Stemmer's Run				
Patapsco Neck	111.13	94	17.13	17
Bayview Junction (*e*)..CC	129.92	94	35.92	36
Baltimore Dep't(*f*)CCLVI	103.33	94	9.33	9

c Port Deposit Branch R. R.
d Susquehanna River, north-east side.
e Northern Central Railway Junction.
f Baltimore and Ohio R. R.

CCLIV. Columbia and Port Deposit R. R.

Elevations on the Columbia and Port Deposit R. R., were copied from a profile furnished by Mr. J. B. Hutchinson, Chief Engineer.
Datum: *Mean* tide at Port Deposit, nearly = Ocean level.

STATIONS.	A. M. T.	Ocean Level.	
Perryville (*a*) CCLIII		(21)	
Port Deposit	8	8	
P. & B. C. R. R. Junc. (*b*) CCLII	35	35	
Conomingo Creek	70	70	
Ball Friar	77	77	
Ark Haven	79	79	
Peach Bottom (*c*)	98	98	
Fishing Creek	108	108	
Fights Eddy	118	118	
McCalls Ferry	168	168	
York Furnace	176	176	
Shank's Ferry	182	182	
Safe Harbor	197	197	
Wislar's Run	228	228	
Washington	231	231	
Columbia (*d*)	240	240	

a Philadelphia, Wilmington and Baltimore R. R.
b Junction with Baltimore Central R. R.
c Peach Bottom R. R. starts from the opposite side of the Susquehanna River. See table CCVI.
d The elevation is in the lower part of Columbia, and is about 4' lower than where the elevation is given on Pa. R. R. "Elevation on Pa. R. R. track in front of passenger station is 244'."

CCLV. Western Maryland R. R.

Elevations of the W. M. R. R., were copied from profile furnished through the kindness of Gen. J. M. Hood, President and Gen'l Manager of the road.
Datum: *Mean* tide at Baltimore = ? Ocean level.

STATIONS.	Tide.	Ocean Level.	
Baltimore, Canton Wharf	20	20	
B. & P. R. R. Crossing (*a*)....CC	150	150	
Oakland			
Arlington			
Mount Hope			
Howardville			
Pikesville			
Greenwood			
McDonough			
Junction			
Owing's Mills	480	480	
Timber Grove			
Reisterstown	600	600	
Glen Morris			
Finksburg			
Patapsco	360	360	
Shamberger's			
Parrs Ridge	680	680	
Tannery			
Westminster (*b*)	680	680	
Avondale			
Smith's Switch			
New Windsor	440	440	
Linwood			
Union Bridge	350	350	
Middleburg			
Frederick Junction (*c*) ...CCVII			
Double Pipe Creek			
Monocacy River	280	280	
Rocky Ridge	370	370	
Loy's			
Graceham			
Mechanicstown	475	475	
Sabillasville			
Blue Ridge Summit (*d*)	1373	1373	
Waynesborough			
Smithsburg			
Chewsville			
Antietam Creek	460	460	
Cumbl'nd Valley Junc. (*e*)CCVIII			
Hagerstown	520	520	
Williamsport	305	305	

a Baltimore and Potomac R. R. (or Northern Central) Crossing.
b Bachman's Valley R. R., no levels obtainable.
c Frederick Division of Penna. R. R. CCVII.
d Montery Springs Summit.
e Cumberland Valley R. R. Level in table CCVIII is feet.

CCLVI. Baltimore and Ohio R. R.

Levels on the B. & O. R. R., were copied from a profile and notes in the office of the Company at Baltimore, by permission of Mr. W. N. Bolling, Engineer.

Datum: The levels are based upon mid tide at Baltimore, and are according to the original survey of the road by Mr. B. H. Latrobe, Chief Engineer, many years ago.

It was impossible to get the levels at all the stations on the road.

STATIONS.	Mean Tide.	Ocean Level.	
Baltimore (Camden Station).....	24	24	
Mount Clair.....	66	66	
Winan's Station (*a*) CC			
Washington Junction (*b*).....			
Ellicotts Mills...	139	139	
Elysville.....			
Woodstock.....			
Marriottsville.....			
Sykesville.....			
Parr's Ridge.....	813	813	
Gaither			
Woodbine.....			
Mount Airy			
Monrovia.....			
Ijamsville			
Hartman's			
Frederick City Junc. (*c*) ...CCIX			
Monocay River.....	262	262	
Frederick City.....	280	280	
Doub's			
Point of Rocks (*d*).....	221	221	
Berlin			
Knoxville (*e*)			
Hagerstown Junction.....			
Sandy Hook.....			
Harpers Ferry (*f*).....	272	272	
Duffield's			
Kearneysville.....			
Vanclieveville....			
Martinsburg.....			
Shepardstown Road	467	467	
North Mountain.....	547	547	
Cherry Run.....	398	398	

a Baltimore and Potomac R. R. Crossing.

b Washington Branch B. & O. R. R. diverges from main line at this point.

c Frederick Branch B. & O. R. R.

d Metropolitan Branch B. & O. R. R. connects with main line. *No levels of this line.*

e Washington County Division B. & O. R. R. joins main line at this point. *No levels of this line.*

f Winchester, Potomac & Strassburg R. R. connects with B. & O. R. R. This is one of the R. R's of the State of Virginia.

STATIONS.	Mean Tide.	Ocean Level.	
Sleepy Creek.....			
Hancock.....(about)	424	424	
Sir John's Run.....	434	434	
Great Cacapon.....			
Willett's Run			
Rockwell's Run.....			
Doe Gully Tunnel	545	545	
Little Cacapon.....	562	562	
South Branch Potomac River....			
Green Spring Run			
Patterson's Creek.....	568	568	
Cumberland (*g*).....CCLIX	639	639	
Brady's Mill.....			
Rawlings.....			
Black Oak Bottom			
New Creek			
Piedmont .....(about)	919	919	
Bloomington.....	993	993	
Frankville			
Swanton.....			
Altamont.....	2620	2620	
Deer Park.....			
Oakland			
Huttons.....			
Cranberry Summit.....	2550	2550	
Rodermer's Tunnel.....			
Rowlesburg.....			
Cheat River.....	1397	1397	
Cassady Summit.....	1856	1856	
Kingwood Tunnel	1820	1820	
Tunnelton.....			
Newburg.....			
Independence			
Raccoon Run.....	1227	1227	
Thornton.....			
Grafton (*h*)	985	985	
Fetterman			
Valley Falls.....			
Texas.....			
Benton's Ferry.....			
Fairmount.....	888	888	
Barnesville			
Barrackville.....			
Farmington.....			
Mannington			
Glover's Gap.....	1150	1150	
Glover's Gap Tunnel	1146	1146	
Burton.....			
Littleton.....			

g Pittsburgh and Connellsville Branch of B. & O. R. R. intersects main line here.

h Parkersburg Branch B. & O. R. R. diverges from main line at this point.

STATIONS.	Mean Tide.	Ocean Level.	
Board Tree Tunnel	1104	1104	
North Fork of Fish Creek	887	887	
Bellton.....			
Welling Tunnel.....	1193	1193	
Cameron	1049	1049	
Easton's			
Roseby's Rock.....			
Moundsville (*i*).....	661	661	
McMechen's Cut.....			
Benwood	648	648	
South Bank of Wheeling Creek			
Wheeling, High Water (*j*).....	637	(663)	

i Here the R. R. strikes the Ohio River bank and ascends hence to Bridgeport, opposite Wheeling; crosses by a bridge and continues west as Central Ohio Division of Baltimore and Ohio R. R.

j Wheeling.—Mr. J. T. Gardner, in his "Elevations of certain datum points," p. 655 of Hayden's Report of 1873, treats fully of the level of the Ohio River at Wheeling, in relation to the levels of the B. & O. R. R., and arrives at the "probable" conclusion that "the B. & O. R. R. results are too low," giving an improbable fall to the Ohio from Steubenville, exceeding 1 foot per mile, which is known to be its true rate of fall, from P. & S. R. R. and C. & P. R. R. surveys. High water at Wheeling is 637′ by B. & O. R. R. survey of 1832, and the "channel" is 588. This is about 30′ too low. Mr. Gardner makes Wheeling H. W. 1852 . . . . . about 663

CCLVII. Cumberland and Pennsylvania R. R.

Levels on the C. & P. R. R. were furnished by Mr. James A. Millholland, Vice-President of the Company, Cumberland, Md.

STATIONS.	Above Tide.		
Cumberland (*a*).....CCLVI	650		
Eckert Branch Junction (*b*).....			
Mount Savage Junction (*c*).....			
C. & P. Junction (*d*).....			
Barrelville.....			
Mount Savage.....	1206		
Frostburg.....	1920		
Neff Run.....			
Lonacoming.....	1560		
Barton.....			
Piedmont (*e*).....	928		

a Baltimore and Ohio R. R.—Level of "Cumberland" in B. & O. R. R., Table CCLVI is 639, which, however, is Mr. Latrobe's original level.

b No levels.

c Bridgeport & Bedford R. R.

d Connellsville & Pittsburgh Branch B. & O. R. R.

e Rejoins the Baltimore & Ohio R. R.

NOTE.—This road runs back of the mountain, west of the river, through the Cumberland Coal Basin.

CCLVIII. Cumberland Turnpike Road.

Levels on the Cumberland Turnpike Road were copied from a report made by Jonathan Knight, Chief Engineer of the Baltimore and Ohio R. R., October 5th, 1835. They were partly taken from a map and profile made by James Schriver, in 1824. Mr. Knight says, in his report, "The levels may be sufficiently accurate for such a road (turnpike), yet are not so exact as levelings taken for a canal or railroad."

Datum: Probably mean tide at Baltimore.

NAMES OF TOWNS, &c.	Above Tide.	
Cumberland.....CCLVI	635	
Frostburg	1890	
Great Savage Mountain Summit	2657	
Savage River, 2 miles from its head	2376	
Little Savage Mountain Summit	2535	
Little Backbone Mountain Summit at (Beall's) Dividing Eastern and Western Waters	2372	
Meadow Mountain Summit (Alleghany Mtn.)	2654	
Castelman's River	2077	
Negro Mountain Summit	2826	
Keyser's Ridge Summit, a spur of Negro Mountain	2843	
Winding Ridge Summit	2534	
Smythfield at Youghiogheny River	1405	
Barren Hill Summit	2450	
Woodcock Hill or Briery Mountain	2500	
Laurel Hill or Most Western Mountain	2412	
Munroe at Western Base of Laurel Hill	1065	
Uniontown	952	
Cauley's Hill	1274	
Brownsville at Monongahela River	873	
Hillsborough	1750	
Washington	1406	
West Alexandria	1797	
Wheeling	748	

CCLIX. Pittsburgh and Connellsville R. R.

Levels on the P. & C. Branch of the B. & O. R. R. were copied from the profile in the office of the Company at Connelsville, Fayette County, Pa.

Datum: As noted on the profile is 200′ *below low water at Pittsburgh*, and 514′ *above mean tide;* therefore 514′ has been added to each elevation, as copied from the profile to get mean tide at Baltimore = ? ocean level.

STATIONS.	Assumed Elevation.	Mean Tide.	
Cumberland (*a*).....CCLVI	124	638	
Mt. Savage Jun. (*b*)(*c*)IX.CCLVII.	170	684	

a With B. & O. R. R.
b Cumb. & Pa. R. R.
c Bedford & Bridgeport R. R.

STATIONS.	Assumed Elevation.	Mean Tide.	
Ellerslie	216	730	
Cook's Mills	270	784	
Bridgeport	424	938	
Fairhope	870.5	1385	
Southampton	104.5	1564	
Glencoe	1119	1633	
Philson's	1347	1861	
Sandpatch Tunnel	1712	2226	
Summit	1772	2286	
Myersdale (*d*) CCLX	1549	2063	
Garrett (*e*) CCLXI	1433.5	1948	
Pinegrove	1360	1874	
Mineral Point (*f*) CCXII	1310.9	1825	
Castleman	1142.6	1757	
Pinkerton	1135	1649	
Shoo-Fly Tunnel	1100	1614	
Brook Tunnel	1044	1558	
Ursina (*g*)			
Confluence	832	1346	
Draketown Run	805	1319	
Egypt	788	1302	
Ohio Pyle	723	1237	
Indian Creek	468	982	
Sand Works	407	921	
White Rock (*h*) CCLXIII	407	921	
Connellsville (*i*) CCLXVI	380	849	
Broad Ford (*j*) CCLYIV	358	872	
Sedgwick	354	868	
Dawson (*k*) CCLXV	350	864	
Laurel Run	342	856	
Oakdale	338	852	
Layton	304	818	
Barring's	290	804	
Jacob's Creek	280	794	
Smith's Mill			
Port Royal	278	792	
Snyder's	274	788	
West Newton	268	782	
Sewickley (*l*) XXXI		(780)	
Armstrong's	265	779	
Robbin's	254	768	
Coultersville	254	768	
Alpsville	254	768	
Osceola	254	768	

d Salisbury & Baltimore R. R. Junction.
e Buffalo Valley R. R.
f Somerset & Mineral Point R. R.
g Coal R. R.
h Fayette and Uniontown Branch R. R.
i S. W. Pa. R. R.
j Mt. Pleasant Branch.
k Hickman Run Branch R. R.
l Youghiogheny R. R., Branch of Pa. R. R. difference of 1' in levels at Sewickley.

STATIONS.	Assumed Elevation.	Mean Tide.	
Ellrod	254	768	
Long Run	251	765	
McKeesport	251	765	
Riverton	251	765	
Saltsburg	251	765	
Port Perry Junction	251	765	
Braddock's	255	769	
City Farm	247	761	
Salt Works	252	766	
Brown's	243	757	
Grove	270	784	
Hazelwood	275	789	
Frankstown	269	783	
Laughlin	256	770	
Copper Works	249	763	
Soho	255	769	
Birmingham Bridge	237	751	
Pittsburgh	237	751	

CCLX. Salisbury R. R.

Levels on the Salisbury R. R. were furnished by Mr. R. I. Batzer, C. E.
Datum: Pittsburgh and Connellsville R. R. at Meyersdale.
This road runs south up Castleman's River, towards the Maryland line.

STATIONS.	Mean Tide.		
Pitts. & Conn. R. R. Junction (*a*) CCLIX	2095		
Meyersdale	2063		
Coal Mines (*b*)	2067		
Romain	2073		
Keystone	2075		
Livengood's Mill	2100		
Salisbury	2131		
Coal Mines (*c*)	2331		

a Junction with Pittsburgh and Connellsville R. R. near Meyersdale, or Myer's Mills.
b Cumberland and Elklich Coal Mines.
c Salisbury and Baltimore Coal Mines.

CCLXI. Buffalo Valley R. R.

Elevations on the Buffalo Valley R. R. were furnished by Mr. S. Philson, President of the Company.
Datum: Pittsburgh and Connellsville R. R.
This road runs north into Somerset County.

STATIONS.	Mean Tide.		
Garrett (*a*).....CCLIX	1947		
Burkholder.....	1992		
Beaghley's.....	2010		
Bitner.....	2044		
Pine Hill.....	2064		
Hanger's	2073		
Berlin.....	2176		

CCLXII. Somerset R. R.

NOTE.—The records of this road were destroyed by fire. It runs north into Somerset County towards Johnstown.

CCLXIII. Fayette Branch, P. & C. R. R.

Levels on this Branch of the Pittsburgh and Connellsville R. R. were copied from a profile in the office of the Company at Connellsville, Pa., through the kindness of Mr. W. H. Taylor, Resident Engineer.

Datum: Mean tide at Baltimore, Md.

This road runs southwest along the west foot of Chestnut Ridge towards the Virginia State line.

STATIONS.	Mean Tide.		
White Rock (*a*).....CCLIX	907		
Fayette.....	924		
Watt's.....	991		
Dunbar.....	1011		
Ferguson.....	1138		
Mt. Braddock.....	1175		
Lemont's.....	1084		
Evans'	1009		
Hoggsett's.....	978		
Uniontown.....	981		

a Junction with Pittsburgh & Connellsville R. R. just above Connellsville.

NOTE.—The other bridge (at Connellsville) carries the southwest Pennsylvania R. R., which also runs up Dunbar Creek to Uniontown.

CCLXIV. Mt. Pleasant Branch, P. & C. R. R.

Data obtained as the last mentioned.

This road runs northeast along the west foot of Chestnut Ridge.

STATIONS.	Mean Tide.		
Broad Ford (*a*).....CCLIX	873		
Morgan's.....	944		
Tinstman's	1076		
Valley Coal Mines	1035		
Fountain Mills.....	1040		
West Overton.....	1045		
Iron Bridge.....	1052		
Stauffer's.....	1057		
Mt. Pleasant.....	1086		
End of Road.....	1083		

a Junction with Pittsburgh and Connellsville R. R. at Broad Ford, 3.2 miles below Connellsville.

CCLXV. Hickman's Run Branch, P. & C. R. R.

Data as above.
This road, one mile long, runs north to Coke Banks.

STATIONS.	Above Tide.		
Dawson Junction (*a*).....CCLIX	872		
Terminus of Road.....	1006		

a Junction with Pittsburgh and Connellsville R. R. near Dawson.

CCLXVI. Southwest Pennsylvania Extension.

Levels on the Extension of Southwest Penna. R. R. were furnished by Mr. John C. Oliphant, Engineer.

Datum is *high tide* in Schuylkill River, at Philadelphia. Add 7′ for ocean level. For the surveys an artificial datum was assumed, as shown in column 1. Column 2 gives this corrected for high tide at Philadelphia. Column 3 corrected for ocean level.

The main road is given in the I series, Table XXX.

This road crosses the Youghiogheny at Connellsville, and keeps up Dunbar Creek over to Uniontown, parallel with the Fayette County Branch of the P. & C. R. R. See Table CCLXIII.

STATIONS.	Assumed Elevation.	Above Tide.	Ocean Level.
Connellsville (*a*).....CCLIX	159.5	908	915
Sub-grade, Pier No. 1.....	153.6	902	909
Ordinary Water in Youghiogheny River, at R. R. Bridge, S. W. Penna. R. R.....	118	866	873

a Crosses *above* P. & C. R. R. here on a Bridge.

STATIONS.	Assumed Elevation.	Above Tide.	Ocean Level.
New Haven	138	886	893
Wheelerville	144	892	899
Dunbar	246.4	995	1002
Ferguson	376.2	1125	1132
Mt. Braddock (*b*)	448	1196	1203
Lemont	274.8	1023	1030
Hoggsett's Mill	205.7	954	961
Uniontown (*c*)	234.2	983	990

b Deep Cut; original surface 485 + 748.5 = 1233.5
c Intersection of Main Street and Broadway.

CCLXVII. Youghiogheny Coal Mine Levels.

Elevations of *Coal openings* on the line of Youghiogheny R. R. furnished by Mr. I. F. Wolf, Engineer Penn Gas Coal Company.

Datum: That of the Pa. R. R.

Youghiogheny Mine, No. 1	720.40
" " " 2	776.40
" " " 4	800.40
Th. Moore's drift at Moore's station P. & C. R. R.	793.40
Markel's Drift at Junction of Yough. R. R	824.44

CCLXVIII. Westmoreland Levels.

Various datum points in Westmoreland County, Pennsylvania, from a survey made by Mr. F. Z. Shellenberg, Superintendent of the Westmoreland Coal Company, Irwin's Station, Penna. R. R.

Datum: That of the Pennsylvania R. R. (Add 7′ for Ocean Level.)

Long Run Presbyterian Church Bench Mark on Door Sill	+ 1150′
Circleville Intersection of Mount Pleasant Turnpike with Greensburg and Pittsburgh Turnpike	1223
Jacksonville, Turnpike east end of town	1152
South Side Mine Mouth Coal	898
Larimer's Coal Mine	961
Ray's Coal Bank; on farm of William Ray's heirs	1052
Robinson's Coal Bank; on farm of R. S. Robinson	989
Bigley's Mines; Mouth of Drain, entry from Armstrong's Osceola Works, P. & C. R. R., at head of Bigley's Main Entry	902
Coal Hollow: Youghiogheny Coal Hollow Coal Company's Mines, between Guffey's and Shaner's Station, P. & C. R. R. Coal	789
Armstrong's Coal, opposite Buena Vista (east)	813
Moore's Coal Mine	812
Suter's Station, P. & C. R. R. Coal	843
Westmoreland Coal Shaft (Coal?)	751
Foster Shaft (Penn Township). Coal	935
Penn Coal Mine, north side of Penn Station, Pa. R. R	927
Kifer's Coal Bank, east of Penn Station, north side of Pa. R. R.	1140
Smith's Coal Bank	1180
Loughner's Coal Bank	1102

Harrison City, two miles north of Manor Station, on Pa. R. R., on *bridge* over Brushy Run 967
Cross Roads, two miles west of Harrison City 1185
Salem: *Intersection* of Freeport and Saltzburg Roads, northeast of Salem. 1231
Salem: Burnt Cabin *Summit*, between Allegheny and Monongahela Waters, between Beaver Run and Turtle Creek, one-half mile northeast of Salem. 1200
Salem Cross Roads (Delmont P. O.). 1255
Salem: Coal at Salem Cross Roads. 1272
Bouquet Village *Road*, opposite Grist Mill 1102
Bouquet Coal 1104
William Duff's Steam Grist Mill, *surface of water* just below Mill. . . 950
King's Bank, Coal at Burnt Cabin Summit. 1203
McQuade's Coal Bank on road leading from Salem Cross Roads to Freeport 1189
John Cochran's Coal Bank. 1132
Thorn Run: *Water* in Run at road crossing Jas. Cochran's farm. . . . 1080
Turtle Creek: *Water* in Creek at northern turnpike crossing, on Waugaman's farm 1051
Turtle Creek: Northern *turnpike* crossing, at Long's. 995
Turtle Creek: *Water* in Creek at Remaly's Mill. 950
Walton's *Summit*, between waters of Turtle Creek and Brushy Run . 1194
Longacre's *Summit* 1187
Brinker's *Summit* 1202
Fink's Run: *Water* at junction with Brushy Run, four miles north of Manor Station, Pa. R. R 1000

CCLXIX. Pittsburgh, Virginia and Charleston R. R.

Levels on the P. V. & C. R. R. were copied from the profile in the office of the company at Pittsburgh, by permission of I. M. Byers, Esq., Superintendent.

Datum:

This road ascends the west bank of the Monongahela River from Pittsburgh to the Virginia State Line, and is in process of completion above Monongahela City. It crosses the river from Pittsburgh to Birmingham on a high bridge.

STATIONS.	Above Tide.	Ocean Level.	
Pittsburgh (*a*).....CCCLII	750		
12th Street, Birmingham.....	786		
18th " "	779		
22nd " "	770		
30th " "	745		
Beck's Run.....	750		
Bird's Run.....	749		
Street's Run.....	745		
West's Run.....	740		
Homestead.....	745		
Patterson's Run.....	742		
Opposite Braddock's.....	730		
Thompson's	749		
Opposite McKeesport.....	725		
Curry's Run (*b*)	734		

a Junction with the Pittsburgh, Cincinnati and St. Louis R. R.
b On bridge.

STATIONS.	Above Tide.	Ocean Level.	
Camden	738		
Rock Run	731		
Pine Run	739		
Peter's Creek	735		
Wylie's	743		
Elizabeth	731		
Walton's	741		
Hodgen's Coal Road	735		
Coal Bluff Road	735		
Houston's Run	740		
Buffalo Coal Works	748		
Mingo Creek	740		
Dry Run	735		
Monongahela City	737		
Pigeon Creek (*c*)	735		
Johnson's Coal Road	750		
Pike Run	719		
West Brownsville (*d*)	758		

c Surface of water at ordinary stage 709.
d In Street in front of Hotel.

VII. ALLEGHENY SERIES.

CCC. Pittsburgh City Levels.

Elevations at different points in the City of Pittsburgh, Pa., were furnished by Mr. William Martin, Assistant Engineer.

Datum: *Low water in the Allegheny River* at the Suspension Bridge, which according to Mr. Jas. T. Gardner's determination, is 699.20′ above the Mean Surface of the Atlantic Ocean. See page 655, Vol. I, Hayden's Geological Survey Report of 1873.

Elevation of Points in City of Pittsburgh, Pa.

BENCH MARKS.	City Datum.	Ocean Level.	
On Window-sill of Monongahela Incline Plane, Check House	407.075	1106.275	
On Belt-course of Union Depot, Main Entrance	47.203	746.403	
On East end Door-sill of Point Breeze Hotel at Intersection of Penn and Fifth Avenue	273.814	973.014	
On Belt-course of Munshall's Distillery, corner Penn Avenue and Water Street	28.198	727.398	
On Door-sill of Post Office	51.554	750.754	
On Embankment of *Lower* (old) Reservoir on Bedford Avenue	165.854	865.044	
On Embankment of *Upper* (old) Reservoir, Bedford Avenue	401.674	1100.874	

BENCH MARKS.	City Datum.	Ocean Level.	
On Flow Line of Highland Avenue (new) Reservoir.....	365	1064.20	
On Flow Line of Herron Hill (new) Reservoir.....	560	1259.20	
On Flow Line of Brilliant Hill (new) Reservoir.....	235	934.20	

CCCI. Allegheny Valley R. R.

Levels on the Allegheny Valley R. R., from Kittaning to Oil City, were copied from notes in possession of Mr. Wainwright, Assistant Engineer, Engineer's Office, Allegheny Valley R. R., Pittsburgh, Pa.

This portion of the road was leveled during the summer of 1875. The elevation at Kittaning was assumed to be 500′ above tide. The difference between the true elevation and the elevation assumed at the Red Bank intersection of the Bennett's Branch R. R. with the main line, was made to be 284′. This must be incorrect.

Great difficulty has been experienced in connecting the levels of this road with those of others in Northwestern Pennsylvania, and no reliance can be placed upon their exactness. They are evidently *too low*, and the error seems to be in the 284′ feet difference; and therefore in the Bennett's Branch Extension Table, CCCII.

For instance, the level at Parker's City is, by this Allegheny Valley R. R. Table, 579.2 + 284 = 863′; whereas, Mr. Lucas makes it 909′, or 46 feet higher. See Section in Carll's Report of Progress, 1874.

Again, at Franklin this Table gives 678.5 + 284 = 963′; whereas, Lake Shore and Michigan Southern (Franklin Division) Table CCCLXII makes it 444.06 (+ Lake Erie) + 573 = 1017′, or 54 feet higher.

Again, at Oil City this Table gives 983′; whereas Oil Creek and Allegheny Valley R. R. (CCCIV) gives 995′, or 12′ higher. And the same in CCCLXXXVII by the Franklin Branch of Atlantic and Great Western.

The levels of points from Pittsburgh up to Kittaning could not be obtained by any efforts. There seem to be no records, profiles or notes of the levels of this part of the line. Pittsburgh is 745′ by Table I; Gardner makes it 746′, and so does Pittsburgh, Fort Wayne and Chicago R. R., Table CCLXXIII.

STATIONS.	Assumed	Tide.	Ocean Level.	
Pittsburgh.....			(745)	
Sharpsburgh.....				
Hulton.....				
Logan's Ferry.....				
Parnassus.....				
Tarentum.....				
Chartiers.....				
Soda Works.....				
West Penn Junction (*a*) XXVI.....			(778)	
White Rock.....				

a With West Penn. R. R. east to Philadelphia.

STATIONS.	Assumed	Tide.	Ocean Level.	
Kelly's.....				
Logansport.....				
Rosston.....				
Kittaning.....	500	784	791	
Cowanshannock.....	498.8	783	790	
Pine Creek.....	502.2	786	793	
Templeton	513.9	798	805	
Mahoning.....	514.4	799	806	
Reimerton.....	526.8	812	819	
Red Bank Junc. (*b*)CCCII	540.9	825	832	
Phillipsburg.....	545.3	829	836	
Brady's Bend.....	546.4	831	838	
Catfish.....	548.5	833	840	
Sarah Furnace.....	551.5	836	843	
Hillsville.....	555.3	839	846	
Monterey.....	564.7	849	856	
Parker City (*c*)...CCCIII	579.2	863	870	
Foxburg	586	870	877	
Emlinton.....	595.2	879	886	
Dotterer's.....	604.9	889	896	
Black's.....	612.6	897	904	
Rockland.....	616.6	901	908	
St. George's.....	624.9	909	916	
Scrub Grass.....	637.7	922	929	
Brandon's.	651.4	936	943	
Foster.....	659.8	944	951	
East Sandy.....	665.4	950	957	
Cochran.....	672.5	957	964	
Franklin(*d*) } CCCLXV / CCCLXII	678.5	963	970	
† Oil City (*e*)....CCCIV	699.2	983	990	

b Junction of Bennett's Branch R. R. Elevation according to profile of Bennett's Branch Ext. of Allegheny Valley R. R. + 824.70, which gives the above mentioned difference of 284', used for reducing the other levels to tide This however depends on the Phila. & Erie R. R. levels, Table , which are as unreliable as those of the Allegheny Valley R. R. The connection between Harrisburg and Pittsburgh, round by the West Branch Susquehanna River, is divisible into three sections, the middle one (Bennett's Branch Extension R.R.) alone being reliable.

c Junction with Parker and Karn's City R. R.

d Junction with Atlantic and Great Western R. R., and with Lake Shore and Michigan Southern (Franklin Division) R. R.

e South Oil City, river rail, main track, opposite lower end of platform of depot. Junction with Oil City and Allegheny Valley R. R.

NOTE.--Seven feet has been added to the second column in the above Table to make the third column agree with levels in Table CCCII.

CCCII. Bennett's Branch Extension R. R.

The levels on the Bennett's Branch Extension, A. V. R. R., were copied from the profile in the office of the A. V. R. R. at Pittsburgh, Pa., through kindness of Mr. H. Blackstone, Chief Engineer.

Datum: Tide water at Philadelphia.

This datum, however, is dependent upon the level of the eastern terminus or Driftwood Junction with the Phil. & Erie R. R. But this is known to be too low, and therefore, the levels of the whole line are too low, and carry down with them those of the Allegheny Valley Main Line, as stated in notes, to Table CCCI.

Mr. Burgin's original level on the P. & E. R. R. at Driftwood was 788'. This Mr. Wilson took for his datum level in the surveys of the Bennett's Branch Extension R. R. across to the Allegheny Valley R. R. Mr. Wilson's levels are given in column 1.

On the profile of the P. & E. R. R. used in Table CCXVI, the level of the point of junction is called 795 (7 feet higher). Column 2 makes this first correction, which helps to lift the Allegheny Valley levels a little, but not near enough.

Column 3 is left blank for a future correction, when the levels of the P. & E. R. R. are lifted, as they must be; for, although they start about right at Sunbury, they are already about 20 feet too low at Williamsport by the Catawissa R. R. (LXV), and by the Northern Central R. R. (CC) lists of levels; and feet too low at Lock Haven by the Pennsylvania R. R. (XV) branch lists. At Emporium also they are 18 feet lower than the Buffalo, N. Y. & Phil. Railroad (CCXIX).

But even this 20 feet added to the previous 7' = 27' will not suffice to lift the west end of this Bennett's Br. Ext. R. R. high enough to cancel the difference at Franklin and Oil City. It is probable, however, that the whole residual error lies on the Allegheny Valley R. R. line.

STATIONS.	Above Tide.	Above Tide.	Corrected Tide.	Ocean Level.
Driftwood Junction (*a*) CCXVI	788	795		
Mix Run	848	855		
Miller's	880	887		
Dent's Run	898	905		
Enz	938	945		
Grant	949	956		
Mount Pleasant	973	980		
Devil's Elbow	993	1000		
Benezette	1014	1021		
Meadic's Run (*b*)	1073	1080		
Caledonia Tunnel (*c*)	1122	1129		
Slabtown Dam	1163	1170		
Hebner's Run	1245	1252		
Clear Run	1385	1392		
Slab Run	1381	1388		
Fall's Creek	1381	1388		
Crooked Run	1378	1385		
Evergreen	1374	1381		
Maghee's	1361	1368		
Panther's Run (*d*)	1362	1369		
Reynoldsville	1351	1358		
Prior Run (*e*)	1342	1349		
Prindible's	1335	1342		

a With P. & E. R. R. near Driftwood. "795" on P. & E. profile.
b Bench mark on Bridge; West abutment, top of Cap-stone, N. E. corner.
c 250' east of Tunnel.
d Cap-stone of east Abutment.
e Cap-stone of east Abutment.

STATIONS.	Above Tide.	Above Tide.	Corrected Tide.	Ocean Level.
McAnnutty Run (*f*)....	1335	1342		
Camp Run.....	1317	1324		
Fuller's Mill.....	1301	1308		
Wolf Run.....	1295	1302		
Cable Run.....	1285	1292		
Iowa Mill.....	1273	1280		
Gooseneck.....	1256	1263		
Bell's Mill.....	1340	1347		
Garrison's Mill.....	1235	1242		
Brookville.....	1209	1216		
Nicholson's Mill.....	1199	1206		
Corder's Run.....	1200	1207		
Puckerty Point.....	1189	1196		
Rattlesnake Run.....	1183	1190		
Baxter's Mill.....	1181	1188		
Heathville.....	1137	1144		
Motter's Run.....	1124	1231		
Bear Tree Run.....	1107	1114		
Maysville.....	1082	1089		
Pine Run.....	1075	1082		
Millville.....	1067	1074		
Indiantown Run.....	1063	1070		
Middle Run.....	1060	1067		
New Bethlehem.....	1054	1061		
Anthony's Neck.....	1025	1032		
Leatherwood.....	1001	1008		
Rock Run.....	940	947		
Buck Lick Run.....	913	920		
Lawsonham (*g*).....	893	900		
Fiddler's Run.....	889	896		
Red Bank Jun. (*h*) CCCI	825	832		
Sligo Branch of A. V. R. R.				
Lawsonham (*i*)...CCCII	891	898		
Stop's Run.....	913	920		
Fiddler's Run (*j*).....	966	973		
9000 feet (*k*).....	1043	1050		
14,000 feet.....	1141	1148		
15,000 feet.....	1161	1168		
17,000 feet.....	1202	1209		
23,000 feet.....	1325	1332		
Benn's Summit.....	1368	1375		
29,000 feet.....	1305	1312		
Cherry Run.....	1198	1205		

f Cap-stone of west Abutment.
g Sligo Branch R. R.
h With Allegheny Valley R. R.
i Junction.
j First crossing; centre of Trestle.
k From the Junction.

STATIONS.	Above Tide.	Above Tide.	Corrected Tide.	Ocean Level.
38,000 feet	1218	1225		
Sligo Summit	1300	1307		
Iron Ore Bank	1228	1235		
52,000 feet	1150	1157		
Little Licking Creek	1122	1129		
Big Licking Breek	1102	1109		
Sligo (*l*)	1090	1097		
End of Road	1085	1092		

Boston Branch of A. V. R. R.

Junction (*m*).....CCCII	1049	1056		
Bridge	1050	1057		
2,000 feet	1075	1082		
3,000 feet	1097	1104		
4,000 feet	1118	1125		
5,000 feet	1138	1145		
6,000 feet	1161	1168		

l Sligo Furnace is served by this road.

m There are no stations marked on the profile of this branch. The levels are given at thousand feet from the point of divergence from the main road.

CCCIII. Parker and Karns City R. R.

Levels of the Parker and Karns City R. R. were taken from notes in possession of Mr. Wm. M. Kipp, Engineer at Parker City. The datum of the preliminary survey was an assumed level 100 feet below the top of the west abutment of the iron bridge then building. This datum (as shown by subsequent surveys in locating the line) is 103.99′ below the top of the free-stone base of the toll house. The bridge rises 8′ going east, and there is a further rise from the end of the bridge to the A. V. R. R. depot of 1.98′, as ascertained by Mr. J. F. Carll, which will make the datum of P. & K. C. R. R. below the A. V. R. R. depot 103.99 + 8 + 1.98 = 113.97′. Elevation A. V. R. R. depot, Parker City 863 — 114 = 749 = datum which added to the elevations as copied from notes should bring levels to tide.

STATIONS.	Above Tide.	Above Tide.	Ocean Level.	
Parker Junc. (*a*)..CCCI		863	870	
Stone House	315	1064	1071	
Martinsburg	330	1079	1086	
Argyle	386.80	1136	1143	
Petrolia	401	1150	1157	
Central Point	410	1159	1166	
Karns City	430.33	1179	1186	

a With Allegheny Valley R. R.

NOTE.—Seven feet has been added to the second column in the above Table to make the third column agree with Tables CCCI and CCCII.

CCCIV. Oil Creek and Allegheny River R. R.

Levels on the Oil Creek and Allegheny River R. R. were copied from the profile in the office of the Company, at Oil City, by permission of C. J. Hepburn, Esq., Superintendent.

Datum: P. & E. R. R.

STATIONS.	Above Tide.	Ocean Level.	
Irvineton (*a*).....CCXV	1158		
Dunn's Eddy.....	1144		
Penna. House.....	1140		
Thompson's.....	1130		
Cobham.....	1121		
Magee.....	1118		
Tidioute	1099		
Trunkeyville.....	1085		
Hickory.....	1078		
Dawson.....	1063		
Jamison.....	1060		
Tionesta.....	1047		
Hunter.....	1048		
Stewart.....	1034		
President.....	1035		
Eagle Rock.....	1033		
Henry's Bend	1022		
Oleopolis	1019		
Walnut Bend.....	1010		
Rockwood.	1003		
Imperial.....	995		
Oil City.....CCCLXVII	995		
McClintock.....	1045		
Rouseville	1026		
Rynd Farm.....	1030		
Tarr Farm.....	1049		
Columbia.....	1054		
Petroleum Centre.....	1076		
Boyd Farm.....	1073		
Pioneer.....	1086		
Shaffer	1120		
Miller's Farm.....	1118		
Titusville.....CCCVIII	1181		
Hydetown.....	1239		
Bridge (*b*).....	1241		
Gray's Mills (*c*).....CCCVII	1266		
Meyer's Switch	1230		
Tryonville.....	1305		
Centreville.....	1284		
Glynden.....	1335		
Spartansburg.....	1444		
Summit.....	1634		
Stewart's Switch.....	1460		
A. & G. W. R. R. Crossing CCCLXV	1433		
Corry (*d*).....CCXV	1420		

a Junction with P. & E. R. R.
b Near Hydetown.
c Union and Titusville R. R. Junction
d Junction with P. & E. R. R.

CCCV. Pithole Valley R. R.

Levels on the Pithole Valley R. R. were furnished by Mr. Aug. Mordecai, Assistant Engineer A. & G. W. R. R. at Meadville, Pa.

STATIONS.	Above Oleopolis	+ Lake Erie	Ocean Level.	
Oleopolis.....CCCIV	0	446	1019	
Wood's Mills.....				
Prather.....	232	678	1251	
Pit hole City.....	290	736	1309	
Pleasantville.....	615	1061	1634	
Enterprise.....	242	688	1261	
Titusville.....CCCVI	162	608	1181	

CCCVI. Dunkirk, Allegheny Valley and Pittsburgh R. R.

Levels on the Dunkirk, Allegheny Valley and Pittsburgh R. R., were copied from a list furnished by Mr. Henry E. Wrigley, C. E., who obtained the levels from the Engineer in charge of the road.

Datum: Lake Erie.

STATIONS.	+ Lake Erie	Ocean Level.	
Titusville.....CCCIV	608	1181	
East Titusville.....			
Pleasant Valley.....	755	1328	
Grand Valley.....			
Star.....	785	1358	
Newton.....	825	1398	
Summit.....	878	1451	
Garland.....	695	1268	
Pittsfield.....	648	1221	
Youngsville.....	611	1184	
Irvineton.....	575	1148	
Gravel Pit.....	595	1168	
Jackson.....	603	1176	
Warren.....	620	1193	
North Warren.....	643	1216	
Russelburg.....	660	1233	
Ackley's.....	663	1236	
Fentonville (*a*).....	670	1243	
Frewsburg.....	688	1261	
A. & G. W. R. R. Crossing CCCLXV	689	1262	
Falconer.....	685	1258	
Ross Mill.....	689	1262	
Vermont.....	722	1295	
Sinclairville.....	757	1330	

a State Line of Pennsylvania and New York.

b Surface of water outlet of Chatauqua Lake 675 + Lake Erie 573 = 1248' Ocean Level.

STATIONS.	+ Lake Erie	Ocean Level.	
Moons	730	1303	
Cassadago (*c*)	736	1309	
Skidmore	744	1317	
Norton's	425	998	
Laona	239	810	
Fredonia	192	765	
Dunkirk (*d*)..CCCLXIII, CLXII	25	598	

c Surface of water 732 + Lake Erie 573 = 1305′ Ocean Level.
d On the list from which the above levels were copied, no elevation was noted at Dunkirk, but as the D. A. V. & P. R. R. and the L. S. & M. S. R. R. use the same depot, the tracks being on the same level, and the elevation as given on profile of L. S. & M. S. R. R. taken as correct, it is therefore adopted as the elevation, at the terminus of this road.

CCCVII. Union and Titusville R. R.

Levels on the Union and Titusville R. R. were furnished through the courtesy of Mr. C. J. Hepburn, Supt. Oil Creek and Allegheny River R. R.
Datum: P. & E. R. R.

STATIONS.	Tide.	Ocean Level.	
O.C.& A.R.R.R.Junc.(*a*).CCCIV	1266		
Hydetown	1239		
Myer's Switch	1230		
Tryonville	1305		
Noble	1285		
Riceville	1356		
Lincolnville	1369		
Lakeville	1399		
Bloomfield	1396		
Union (*b*).....CCXV	1257		

a Junction with Oil Creek and Allegheny River R. R. at Titusville.
b Junction with Phila. and Erie R. R.

CCCVIII. Pennsylvania and Petroleum R. R.

Levels on the Pennsylvania and Petroleum R. R. were furnished by Mr. Aug. Mordecai, Asst. Eng. A. & G. W. R. R., Meadville, Pa.
Datum: Lake Erie.

STATIONS.	+ Lake Erie	Ocean Level.	
Titusville.....CCCIV; CCCV	608	1181	
Newton's Mills	685	1258	
Athens Mills	693	1266	
Little Cooley,	630	1203	
Teeple Town	631	1204	
Cambridge	585	1158	
Edinboro	639	1212	
Summit	705	1278	
McKean's Corner	480	1053	
Erie.....CCCLXIV			

NOTE.—The above levels are from the preliminary survey. The road is not yet built, but the proposed line is from Titusville to Erie.

CCCIX. (a) Buffalo, Corry and Pittsburgh R. R.

Levels on the Buffalo, Corry and Pittsburgh R. R. were obtained in Oil City, through kindness of Mr. C. I. Hepburn, Supt. O. C. & A. R. R. R.

STATIONS.	Above Tide.		
Corry Junction..CCXV, CCCIV, CCCLXV	1423		
Childs	1474		
State Line	1417		
Clymer	1146		
Panama	1545		
Sherman	1568		
Summerdale	1629		
Mayville	1300		
Prospect	1221		
Brockton (*b*).....CCCLXIII	672		

a The levels on this road are supposed to be correct, and may be entirely so, but the profile from which the elevations were copied is indefinite as to the exact location of the stations.

b Junction with L. S. & M. S. R. R. Elevation on L. S. & M. S. R. R. at this point is 724′ above Mean Surface of Atlantic Ocean.

VIII. OHIO LINE SERIES.

CCCL. Pittsburgh, Cincinnati and St. Louis R. R.

Levels of the Pittsburgh, Cincinnati & St. Louis Railroad, were copied from profile in the office of the Company at Pittsburgh, Pa. The profile was furnished by Mr. S. M. Felton, Jr., Gen'l Supt.

Datum: Pennsylvania R. R. levels? Add 7′ for Ocean level.

STATIONS.	Mean Tide.	Ocean Level.	
Pittsburgh (*a*).....I	(738)	(745)	
Birmingham (*b*)	760	767	
Jones' Ferry	75 7	764	
Temperanceville	762	769	
Sheridan	864	871	
Cork Run	874	881	
Ingram	880	887	
Broadhead	872	879	
Cemetery Crossing	867	874	
Bridge, No. 3	824	831	
Bridge, No. 4	787	794	
Bridge, No. 5	775	782	
Mansfield (*c*).....CCCLI	775	782	
Walker's Mill	820	827	
Oakdale	908	915	
Noblestown	923	930	
Willow Grove	988	995	

STATIONS.	Mean Tide.	Ocean Level.	
McDonald's	991	998	
Primrose	1023	1030	
Bulger	1146	1153	
Bridge, No. 17	1222	1229	
Burgettstown	1001	1008	
Dinsmore	1082	1089	
Bridge, No. 19	875	882	
Paris Road	858	865	
Bridge, No. 22	829	836	
Collier's (*d*)	826	833	
Holliday Cove			
Edgington (*e*)			
Steubenville (*f*) CCCLV			

a Pittsburgh Union Depot (746′, Gardner.)
b South side of Ohio River.
c Junction with Chartier's R. R.
d In Virginia.
e East side of Ohio River.
f West side of Ohio River and junction with Cleveland and Pittsburgh River Division R. R.

The levels of this road through Ohio are given on page 670, Vol. 1, Ohio Gelogical Survey, 1873; beginning with Steubenville, Washington Street = 155′.

CCCLI. Chartiers R. R.

Elevations on the Chartier's Branch R. R., were furnished by Mr. N. I. Becker, Chief Engineer, P. C. & St. L. Railway, Columbus, Ohio.

Add 7′ to reduce to Ocean level, and substract 1′ for the discrepancy at Mansfield, = 6′.

STATIONS.	Mean Tide.	Ocean Level.	
Mansfield (*a*) CCCL	776	782	
Leasdale	802	808	
Woodville	807	813	
Bridgeville	825	831	
Boyce's	868	874	
Hill's	873	879	
Greer's	896	902	
Van Emmau's	925	931	
Cannonsburg	936	942	
Houston's	952	958	
Ewing's Mills	981	987	
Cook's	1006	1012	
Washington	1049	1055	

a Junction with Pittsburgh, Cincinnati and St. Louis R. R. In table CCCLXXII 775′.

CCCLII. Hempfield R. R.

Elevations on the Hempfield Railway, were furnished by Mr. W. N. Bolling, Engineer B. & O. R. R.

Datum: Mean tide at Baltimore, Md., equal Ocean level. (No connection can be made at Washington between the Hempfield and Chartier's R. R. lines.)

STATIONS.	Mean Tide.	Ocean Level.	
Washington (*a*)..... CCCLI	(1049)	(1055)	
Thompson's Mills.....	699	699	
Chartier.....			
Taylorsville	1008	1008	
Claysville	683 (?)	683(?)	
Vienna.....			
West Alexandria.....	1099	1099	
Valley Grove.....			
Point Mills.....	896	896	
Roney's Point			
Triadelphia.....	734	734	
Elm Grove.....	683	683	
Carbon			
Mt. De Chantel.....	674	674	
Wheeling (*b*).....	644	644	

a Continuation of the Chartier's R. R.
b North and Water Streets 644'. Market Place 662'.

CCCLIII. Pittsburgh, Fort Wayne and Chicago R. R.

Levels of Pittsburgh, Fort Wayne and Chicago R. R., were copied from the profile (in the office at Pittsburgh), furnished through the kindness of Mr. F. S. Slataper, Chief Engineer.

Datum: Lake Erie. Accepted level of Lake Erie above Ocean level is 573'.

The third column adds 1' to reduce the levels of the second columns to harmony with those of the Pennsylvania R. R.

It is thus seen that the Depot at Pittsburgh is established from the Atlantic side and from the Lake Erie side, with a probable error of about one foot.

STATIONS.	+ Lake Erie	Ocean Level.	Ocean Level.
Pittsburgh (*a*) I	173.10	746	745
Allegheny.....	165.82	739	738
Outer Depot.....	191.85	765	764
Wood's Run.....	158.65	732	731
Jack's Run.....	156.50	729	728
Bellevue.....	156.50	729	728
Emsworth.....	153.04	726	725
Dixmont.....	149.77	723	722
Glendale	149.30	722	721

a Pittsburgh Union Depot.

STATIONS.	+Lake Erie	Ocean Level.	Ocean Level.
Haysville	149.30	722	721
Sewickley	164.30	737	736
Edgeworth	152.80	726	725
Leetsdale	143.44	716	715
Fair Oaks	143.44	716	715
Economy	143.44	716	715
Economy Switch	143.44	716	715
Baden	138.24	711	710
Remington	138.24	711	710
Freedom	130.94	704	703
Rochester (*b*).....CCCLV	134.24	707	706
New Brighton	178.12	751	750
Beaver Falls	198.83	772	771
Sullivan	293.15	866	865
Wallace Run	322.84	896	895
Homewood (*c*).....CCCLIX	376.76	950	949
Highland	471.28	1044	1043
Summit Cut	481.71	1055	1054
Darlington	408.85	982	981
New Gallilee	385.29	958	957
Enon (*d*).....434	421.61	995	994
State Line.....472			
Palestine.....455	422.46	995	994
Leslie's Run.....479			
New Waterford.....503			
Bull Creek.....515½			
Columbiana.....555			
Mill Creek.....534			
Beaver Creek.....487½			
Green Creek.....461			
Gr. Cr. Siding.....454			
Middle York.....461			
Franklin.....506			

b Junction with Cleveland and Pittsburgh.
c New Castle Branch R. R.
d From here on the figures on page of the Geol. Survey of Ohio, Vol. I, 1873. Between Columbiana and Franklin is a station now called Leetonia where the New Lisbon R. R. joins. Neither name nor elevation of this point is given, and therefore no connection can be made with Warren by this line.

CCCLIV. Ohio River Water Levels.

Elevation of points above tide from report of Col. W. Milnor Roberts to Canal Commissioners, November, 1840.

	+Lake Erie	Ocean Level.	
Ohio River at Beaver	93	666	
New Castle Pool	222	795	
Conneaut Lake	509.50	1082.50	
Franklin (*a*)	381.50	954.50	
Allegheny River at Pittsburgh (*b*)	120.50	693.50	

a This datum is especially valuable in the final determination of the absolute level of the Allegheny Valley R. R. system centering here. But the

CCCLV. Cleveland and Pittsburgh R. R.

Levels of the Cleveland and Pittsburgh R. R., were copied from profile in office of Mr. Isaiah Linton, Chief Engineer, Ravenna, Ohio.

Datum: Lake Erie; 573′ above Ocean level.

STATIONS.		Above Lake Erie.	Above Tide.	
Rochester (*a*)..CCCLIII		137	710	
Beaver (*b*)	138	137	710	
Industry.....	125	128	701	
Smith's Ferry.....	125	126	699	
Ohio State Line		133	706	
Liverpool.....	120	120	693	
Wellsville	115	115	688	
Linton.....	121	121	694	
Hammondsville	115	115	688	
Salineville	306	306	879	
Yellow Creek (as below)				
Yellow Creek Summit..	543		1116	
Sandy Summit.....	612		1185	
Bayard	503		1076	
Mahoning Summit.....	627		1200	
Alliance	516		1086	
Beech Creek (water)....	446		1019	
Beech Creek (rail).....	471		1044	
Lima.....	525		1098	
Atwater.....	560		1133	
Summit in Atwater.....	603		1176	
Rootstown	550		1123	
Ravenna Public Square..	560		1133	
Ravenna Station.....	530		1103	
P. &. O. Canal	495		1068	
P. & O. Canal, rail on bridge	509		1082	
Cuyahoga River water..	456		1023	
Cuyahoga River bridge..	474		1047	
Hudson Village.....	547		1120	
Hudson Station.....	480		1053	
Macedonia.....	420		993	
Tinker's Creek, (below rail).....	120		693	
Tinker's Creek.....	248		821	
Bedford.....	368		941	
Mill Creek.....	210		783	
Newburg	224		797	
Cleveland Euclid street avenue	95		668	
Cleveland Machine shop	56		629	

a Junction with Pitts. Ft. W. & Chicago R. R. 137, (710) is at 350 feet from east end of Bridge. At Rochester Station of that road the elevation is 707.24.

b At Beaver commences a series of levels taken from page 669 of Vol. I, Ohio Geology, 1873.

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height of the R. R. track about Allegheny River water at Franklin has not been obtained.

b Mr. Gardner quotes from report of City Engineer, March 15, 1871, (page 655, Hayden's Report of 1873), for Pittsburgh:

Low water, City Datum 699.20
High water, 1852 . . . . . 729.88
High water, 1832 . . . . . 732.95

CCCLVI. River Division C. & P. R. R.

STATIONS.	+Lake Erie	Ocean Level.	
Yellow Creek (as above) (*a*)			
McCoy's.....	111	684	
Elliotsville.....			
Sloan's.....	125	698	
Jeddo.....			
Brown's			
Steubenville (*b*).....CCCL	90	663	
Mingo Junction.....			
Lagrange.....			
Rush Run.....			
Portland.....	90	663	
Yorkville.....			
Deep Run.....			
Martin's Ferry	86	659	
Bridgeport (*c*).....CCLVI			
Bellaire (*d*).....CCLVI	82	635	

a Down the west bank of the Ohio.
b Junction with Pittsburgh, Cincinnati and St. Louis.
c Junction with Baltimore and Ohio R. R.
d Junction Central Div. Balt. and Ohio R. R.

CCCLVII. Beaver Levels.

Bench Marks in vicinity of Beaver, Pa., furnished by Mr. James Harper, County Surveyor, who received the information from notes of Mr. J. N. Hoag, U. S. Engineer.

Bench Marks.

23 Cross cut on door sill of National Plow *Company's building in Rochester*, west door, river front 690.365

26 N. E. corner French and Quay's fire brick works, main building, opposite *Beaver station* on east end top of rubble masonry. Cut on top of rock with cross beside it 688.946

25 Cut and marked with a cross on a flat stone 40 feet from foot of alluvial bank toward river, and opposite a point 50′ west of west end of platform at *Beaver station* 670.348

The above levels were brought from Pittsburgh from a Bench, whose reference above main tide was given by the City Engineer, as determined by the Pennsylvania R. R. level.

CCCLVIII. New Castle and Beaver Valley R. R.

Levels on the New Castle and Beaver Valley R. R., were obtained at Pittsburgh, Pa., through the kindness of Mr. F. S. Slataper, Chief Engineer, P. F. W. & C. R. R. (Late survey).

Datum: Lake Erie, 573′ above Ocean level.

This is part of the Ashtabula, Youngstown and Pittsburgh R. R.

STATIONS.	Lake Erie.	Ocean Level.	
Homewood (*a*).....CCCLIII	376.76	950	
Clinton	326.97	900	
Thompson's.....	286.53	860	
Wampum.....	228.44	801	
Newport	239.36	812	
Moravia	233.02	806	
Lawrence Junction (*b*).....	201.09	774	
Mahonington	216.04	789	
New Castle (*c*).....	230.29	803	
Covert's Mills	217	790	
Edenburg.....	229.6	803	
Seymour.....	224.3	797	
Hilltown	225.6	799	
Quakertown.....	244.2	817	
Lowell	252.8	826	
Nebo	266.5	839	
Struthers.....	263	836	
Haselton	257.9	831	
Youngstown.....	264.4	837	
Brier Hill.....			
Girard.....			
Niles			
Warren			
A. & G. W. R. R. (*d*).. CCCLXV			
Champion.....			
Bristolville			
Oakfield			
Bloomfield.....			
Orwell			
Rock Creek.....			
Eagleville.....			
Austenburg.....			
Ashtabula (*e*) CCCLXIII			

a Pittsburgh, Fort Wayne and Chicago R. R.

b Junction with Erie and Pittsburgh R. R. at Lawrence. *R. R. track at this point 40′ above water in river.*

c Junction with New Castle and Youngstown Branch of Pitts. Ft. Wayne and Chicago R. R.

d Atlantic and Great Western R. R.

e Lake Shore and Michigan Southern R. R.

CCCLXVIII. Beaver Coals, &c.

Levels of Coal Basins and other points from report of W. G. Darley, Chief Engineer of New Castle and Franklin R. R., Oct. 7, 1864.

	Above Lake Erie.	Above Ocean Level.	
New Castle	220	793	
Brier Hill (Mahoning Valley)	356	929	
Hottenburgh Lower Vein	520	1093	
Sandy Lake	740	1313	
Sandy Lake, Lower Vein	540	1113	
Harrisville	806	1379	
Gillande Summit	576	1149	
Franklin	417	990	
Mercer	500	1073	

CCCLIX. New Castle and Franklin R. R.

Levels of the New Castle and Franklin R. R., were copied from a profile of the road furnished by Mr. A. Vandivoort, Supt.

Datum: Lake Erie, 573′ above Ocean level.

STATIONS.	+Lake Erie	Ocean Level.	
New Castle (*a*).....CCCLVIII	220.50	793	
Eastbrook	333	906	
Graham's	334	907	
Wilmington	355	928	
Neshanock Falls	419	992	
Volante	462	1035	
Leesburg	473	1045	
Nelson	487	1060	
Hope Mills	534	1107	
Mercer (*b*).....CCCLXI	524	1097	
Turner's	571	1144	
Jackson Centre	684	1257	
Garvin	754	1327	
Summit	815	1388	
Coulson	704	1277	
Stoneboro (*c*).....CCCLXIII	598	1171	

a Junction with New Castle and Beaver Valley R. R.
b Junction with Shenango and Allegheny R. R.
c Junction with Franklin Division L. S. & M. S. R. R.

CCCLX. Erie and Pittsburgh R. R.

Levels on the Erie and Pittsburgh R. R. were copied from the profile in the office at Erie, through the kindness of Mr. E. N. Beebout, Asst. Engineer.

Datum: Lake Erie. 573′ above Ocean level.

a Junction with New Castle and Youngstown Branch of Pittsburgh, Fort Wayne and Chicago R. R. Table CCCLVIII.
b Crossing of A. & G. W. R. R. See Table CCCLXV.
c Crossing, Franklin Division, L. S. & M. S. R. R. See Table CCCLXII.

STATIONS.	+ Lake Erie	Ocean Level.	
New Castle (*a*).....CCCLVIII	236	809	
Harbor Bridge.....	243	816	
Nashua.....	248	821	
Pulaski.....	253	826	
Middlesex.....	260	833	
Wheatland.....	268	841	
Sharon.....	280	853	
Sharpsville.....	375	948	
Clarksville.....	321	894	
Transfer.....	417	990	
A. & G. W. R. R. Crossing (*b*) CCCLXV.....	357	930	
Shenango.....	368	941	
Greenville.....	388	961	
Jamestown (*c*).....CCCLXII	406	979	
Kasson's.....	538	1111	
Espyville.....	515	1088	
Linesville	460	1033	
Summit (*d*).....	586	1141	
Conneautville.....	493	1066	
Spring.....	388	961	
Albion.....	284	857	
Crosses.....	192	765	
Girard (*e*).....CCCLXIII	124	697	
Fairview			
Swansville.....			
Erie CCCLXIII			

d The elevation given at a point near Summit is 573′ above Lake Erie = 1146′ above Ocean level.

e Junction with L. S. & M. S. R. R. near Girard.

CCCLXI. Shenango and Allegheny R. R.

Levels on the Shenango and Allegheny R. R. were furnished through the kindness of Mr. Aug. Mordecai, Assistant Engineer A. & G. W. Railway, Meadville, Pa.

Datum: Lake Erie. 573′ above Ocean Level.

STATIONS.	+ Lake Erie	Ocean Level.	
Harrisville.....	767	1340	
Pinegrove.....	677	1250	
Pardoe.....	632	1205	
Mercer.....	535	1108	
Cool Spring.....	554	1127	
Freedonia.....	604	1177	
New Hamburg.....	585	1158	
Shenango.....	364	937	
Greenville (*a*).....CCCLX	388	961	

a The Shenango and Allegheny R. R. connects with the Erie & Pittsburgh R. R. at Greenville.

CCCLXII. Franklin Division, Lake Shore.

Levels on Franklin Division of Lake Shore and Michigan Southern R. R. were copied from the profile in the office of the Company at Cleveland, Ohio, by permission of Mr. J. D. Hawks, Asst. Engineer.

Datum: Lake Erie. 573′ above Ocean level.

STATIONS.	+ Lake Erie	Ocean Level.	
Oil City, east (*a*).....CCCI	436.80	1010	
Oil City (*b*)..CCCIV, CCCLXVII	436.80	1010	
Reno (*c*).....CCCLXVII	444.50	1017	
Two Mile Run.....	422.00	995	
Franklin (*d*).....CCCLXVII	444.06	1017	
Midway.....	423.01	996	
Summit.....	592.02	1165	
Polk.....	511.07	1084	
Raymilton.....	564.88	1138	
Midway.....	600.88	1174	
Naples.....	591.78	1165	
Stoneboro.....	598.08	1171	
Coal Branch.....	626.08	1199	
Clark's.....	591.30	1164	
Hadley's.....	497.09	1070	
Salem.....	424.51	998	
A. & G. W. R. R. Crossing (*e*) CCCLXV.....	414.10	987	
Midway.....	510.00	1083	
Jamestown (*f*).....CCCLX	416.78	990	
Turner's.....	487.37	1060	
Simond's.....	483.72	1057	
Williamsfield.....			
Andover.....	522.20	1095	
Richmond.....			
Dorsett.....	444.78	1018	
Jefferson.....	368.07	941	
Plymouth.....	281.20	854	
Ashtabula (*g*).....CCCLXIII	74.52	648	

a Connects with Allegheny Valley R. R. See Table CCCI.

b Connects with Oil Creek and Allegheny River R. R., see Table CCCIV, and with Franklin Branch of the Atlantic and Great Western R. R. See Table CCCLXVII.

c Connects with Franklin Branch of the Atlantic and Great Western R. R. See Table CCCLXVII.

d Connects with Franklin Branch of the Atlantic and Great Western R. R See Table CCCLXVII.

e Crossing, Atlantic and Great Western R. R. near Salem. See Table CCCLXV.

f Crossing, Erie and Pittsburgh R. R. See Table CCCLX.

g Junction with Main Line of L. S. & M. S. R. R.

CCCLXIII. Lake Shore and Michigan Southern R. R.

The elevations of the Lake Shore and Michigan Southern R. R. were obtained at Cleveland, Ohio, through the kindness of Mr. J. D. Hawks, Assistant Engineer.

Datum: Lake Erie. 573′ above Ocean level.

STATIONS.	+ Lake Erie	Ocean Level.	
Dunkirk (*a*).....CLXII, CCCVI	24.94	598	
Morian's.....	53.15	626	
Brockton (*b*).....CCCVI	151.11	724	
Portland.....	121.24	694	
Westfield.....	123.66	697	
Ripley Crossing.....	163	736	
Ripley.....	176.75	750	
State Line.....	212.18	785	
Northeast.....	231.4	804	
Moorhead's.....	194.6	768	
Harbor Creek.....	157.	730	
Wesleyville.....	123.55	697	
Erie (*c*).....CCXV	112.5	686	
Swanville.....	162	735	
Fairview.....	162	735	
Girard (*d*).....CCCLX	143.72	717	
Springfield.....	90	663	
Conneaut.....	78	651	
Amboy.....	107.75	681	
Kingsville.....	98.40	671	
Ashtabula (*e*).....CCCLX	74.52	648	

a Connects at Dunkirk with Erie R. R., Table CCXII, and with the Dunkirk, Allegheny Valley and Pittsburgh R. R. See Table CCCVI.

b Connects at Brockton with the Buffalo, Corry and Pittsburgh R. R. See Table CCCIX.

c Connects at Erie with Philadelphia and Erie R. R. See Table CCXV.

d Connects at Girard with the Erie and Pittsburgh R. R. See Table CCCLX.

e Franklin Division diverges from the Main Line at Ashtabula. See Table CCCLXII.

CCCLXIV. Erie City Levels.

Elevations of points in the City of Erie, Pa., were furnished by Mr. Irvin Camp, City Engineer.

Datum: Lake Erie. 573′ above Ocean level.

STATIONS.	Above Lake Erie.	Ocean Level.	
Chestnut Street, at Second Street (Lake Bluff).....	70	643	
Chestnut and 26th Street.....	190	763	
Water in Reservoir, City Water Works.....	235	808	

CCCLXV. Atlantic and Great Western R. R.

The levels on Atlantic and Great Western Railway were copied from a profile of road in the office of the Company at Meadville, Pa.

Datum: Lake Erie. 573′ above Ocean level.

STATIONS.	Above Lake Erie.	Ocean Level.	
Salamanca (*a*).....CLXII	811?	1384	
Bucktooth.....	798	1371	
Red House.....	771	1344	
Cold Spring.....	785	1358	
Steamburg.....	831	1404	
Randolph.....	702	1275	
Waterboro.....	690	1263	
Kennedy.....	676	1249	
Poland	694	1267	
Levant.....	683	1256	
Jamestown (*b*).....CCCVI	748	1321	
Ashville.....	777	1350	
Panama.....	855	1428	
State Line.....	885	1458	
Freehold.....	974	1547	
Columbus.....	864	1437	
Corry (*c*)..CCCIV,CCCV,CCCIX	866	1439	
Concord.....	780	1353	
Union	724	1297	
Mill Village.....	630	1203	
Miller's	579	1152	
Cambridge.....	585	1158	
Venango.....	556	1129	
Saegertown.....	534	1107	
Meadville.....	504	1077	
Franklin Junction Branch (*d*) CCCLXVII.....	497	1070	
Sutton's.....	526	1099	
Evansburg	707	1280	
Adamsville.....	572	1145	
Sugar Grove.....	449	1022	
Greenville.....	384	957	
Shenango (*e*).....CCCLXI	371	944	
Transfer (*f*).....CCCLX			
Clarksville.....	412	985	
Crawford's.....	318	891	
Orangeville.....	370	943	
Burghill	483	1056	
Johnson's Summit.....	553	1126	
Baconsburg.....	390	963	
Warren.....	327	900	
Leavittsburg (*g*).....CCCLXVI	322	895	

a Junction with Erie R. R. See Table CLXII.

b Crossing, Dunkirk, Allegheny and Pittsburgh R. R. See Table CCCVI.

c Junction with O. C. & A. R. R. R.; see Table CCCIV. Philadelphia & Erie R. R., Table CCXV. Buffalo, Corry and Pittsburgh R. R., CCCIX.

d Franklin Branch of A. & G. W. R. R. diverges from Main Line three miles southeast of Meadville. See Table CCCLXVII.

e Junction with Shenango and Allegheny R. R. See Table CCCLXI.

f Crossing, Erie and Pittsburgh R. R. See Table CCCLX.

g Junction with Mahoning Division of A. & G. W. R. R. See Table CCCLXVI.

CCCLXVI. Mahoning Division, A. & G. W. R. R.

STATIONS.	Above Lake Erie.	Ocean Level.	
Colman's (*a*)	265	838	
State Line	259	832	
Hubbard's	328	881	
Veach Mine	350	923	
Doughten's	384	957	
Thornhill	280?	853	
Youngstown	290	863	
Brier Hill	338	911	
Girard	310	883	
Niles (*b*)	336	909	
Warren (*c*)	327	900	
Leavittsburg	322	895	
Braceville	340	913	
Windham	372	945	
Garrettsville	455	1028	
Mantua	536	1109	
Aurora	515	1088	
Pond	450	1023	
Solan	457	1030	
Plank Road	469	1042	
Newburg	240	813	
Cleveland	24	597	

a Junction with Main Line, A. & G. W. R. R.

b Junction with Niles and New Lisbon R. R.

c Junction with Main Line, A. & G. W. R. R.

CCCLXVII. Franklin Branch, A. & G. W. R. R.

STATIONS.	Above Lake Erie.	Ocean Level.	
Junction (*a*)	497	1070	
Shaw's Landing	524	1097	
Cochranton	488	1061	
Evan's Bridge			
Utica	457	1030	
Sugar Creek	430	1003	
Franklin (*b*) CCCLXII	399	972	
Reno	441	1014	
Oil City (*c*) ..... CCCI, CCCIV	422	995	

a Junction with Main Line A. & G. W. R. R. about three miles southeast of Meadville.

b Connects with the Franklin Division of the L. S. & M. S. R. R. See Table CCCLXII.

c Junction with Allegheny Valley R. R., Table CCCI; and with Oil Creek & Allegheny River R. R. See Table CCCIV.

CCCLXVIII. Sharon Branch, A. & G. W. R. R.

STATIONS.	Above Lake Erie.	Above Tide.	
Junction (*a*).	329	902	
Sharon.	285	858	
End of Road.	275	848	

a Junction with Main Line, A. & G. W. R. R., near Sharon.

APPENDIX.

Mountain Summit Levels.

Statement of elevations of Summits of dividing grounds of Eastern and Western Waters.

SUMMITS.	Tide.	Ocean Level.	
Nescopeck, N. P. R. R.	1635		
Elk & West Creek, P. & E. R. R.	1677		
Sugar Run Gap.	2161		
West of Olean, N. Y. & E. R. R.	1672		
Blair's Gap, Allegheny & Portage Railroad.	2339		
Wilson's Gap, B. & O. R. R.	2620		
Sand Patch, P. & C. R. R.	2290		
Clarion, P. & E. R. R.	1979		
Catawissa Extension of Little Schuylkill R. R.	1450		
Elmira, N. Y. & E. R. R.	1419		
Chambersburg & Pittsburgh (*a*).	2547		

NOTE.—The above levels were copied by Mr. G. W. Leuffer from Mr. Strickland Kneass' memorandum, April 4th, 1866, and are supposed by Mr. Leuffer to be from surveys made by Col. Charles H. Schlatter, in 1838 or 1839.

a Summit between Chambersburg and Pittsburgh, on turnpike.

Clearfield County Levels.

Statement of levels in the Clearfield Region furnished by Mr. E. M. Leuffer, Civil Engineer. Add 3' for Ocean level.

STATIONS.	Tide.	Ocean Level.	
Tyrone Junction of T. & C. R. R. and Pa. R. R.	892	895	
Vanscoyoc.	1402	1405	
Gardner's.	1553	1556	
Mt. Pleasant.	1759	1762	
Emigh's Gap Summit.	2025	2028	
Emigh's Gap Summit, Natural Surface of ground.	2036	2039	
Osceola.	1473	1476	
Pool, Osceola Dam.	1444	1447	

STATIONS.	Tide.	Ocean Level.	
Mouth of Beaver Run	1444	1447	
" Bear Run	1467	1470	
" Mountain Branch	1485	1488	
" Whiteside's Run	1488	1491	
" Wilson Run	1633	1636	
Crest of Allegheny Mountain at Middle Summit, 3 Spring Gap and source of Moshannon Cr.	2233	2236	
Crest of Allegheny Mountain at Northern Summit, 3 Spring Gap	2278	2281	
Crest of Allegheny Mountain, one mile east of Northern Summit, 3 Spring Gap, and highest ground	2611	2614	
Crest of Allegheny Mountain in gap between north fork of Sinking Run and Mountain Branch	2406	2409	
Crest of Allegheny Mountain in gap between Laurel Run and tributary of Mountain Branch	2364	2367	
Crest of Allegheny Mountain in gap between Bear Run and Mount Pleasant Run	2221	2224	
Hale's Coal Bank	1638	1641	
Davis' Coal Bank on pike, two miles east of Janesville	1670	1673	
Little Muddy Run at pike crossing near Janesville	1450	1453	
Whiteside's Gap in divide between Moshannon & Clearfield waters	1618	1621	
Confluence of Big and Little Muddy Runs	1321	1324	
Spruce Flat Summit in divide between Beaver Run and Clearfield waters	1603.5	1607	
Confluence of Big Muddy and Clearfield Creek, near Madeira	1302	1305	
Houtzdale, Level of top of rail of Railroad at Depot	1492	1495	
Franklin Colliery Level of bottom of Coal Vein	1526	1529	
Surface of water in Clearfield Creek at Glen Hope	1319	1322	
Surface of water in Big Muddy Run at turnpike crossing, 1½ mile west of Janesville	1345	1348	
Hagerty's cross roads	1568	1571	
Stephen's Summit in Clearfield and Moshannon divide	1722	1725	
Sand Spring, source of the Mountain Branch	2428	2431	
Moshannon Mines three miles west of Osceola (?)	1465	1468	

Centre County Levels.

Elevations of points on experimental line from Bellefonte to Spring Mills, by Mr. J. L. Sommerville, R. E., Bellefonte and Snow Shoe Railroad.
Add 7' for Ocean Level.

STATIONS.	Tide.	Ocean Level.	
Crossing Nittany Mountain at Heckley Furnace	1867	1874	
Head of Penn's Creek (water)	1129	1136	
Spring Mills intersection with L. C. & S. C. R. R.	1072	1079	
Bellefonte and Lewistown turnpike crossing, Nittany Mountain	1650	1657	

CVII. Lehigh and Susquehanna R. R.

See page 43 above.
The following tables have just been received from Mr. John W. Crellin, A. E., in a letter dated, Mauch Chunk, May 1, 1876.

STATIONS.	Elevations.	Ocean Level.	
Top of rail L. V. Track at			
Phillipsburg CXIV	217.4		
Easton CVII	215.1		
Glendon	215.06		
Hopes	219.51		
Freemansburg	221.73		
Bethlehem	235.54		
Bethlehem Junction	239.35		
Allentown	257.23		
Lower Catasaugu	271.02		
Upper Catasaugu	283.53		
Lauback's	303.82		
Siegfried's Bridge	315.03		
Priechler's	343.95		
Lockport	356.42		
Walnut Port	371.43		
Lehigh Gap	392.73		
Hazardville	416.83		
Bowmansville	435.77		
Parryville	443.33		
Weissport	475.50		
Lehighton	493.71		
Mauch Chunk	532.3		
Coal Port	584.7		
Penn Haven Junction	708		
Penn Haven	723.9		

CIX. Nesquehoning Valley R. R.

See page 44, above.

STATIONS.	Elevations.	Ocean Level.	
Nesquehoning	801.116		
Hauto	1005.19		
Hometown	1175.64		
Hawk Switch	1221.43		
Pamanend	1287.43		

CXII. Lehigh and Lackawanna R. R.

See page 45, above.

STATIONS.	Elevations.	Ocean Level.	
Bethlehem Junction	239.35		
Shimer's	289.129		
Ritter's	298.67		
Brodhead's	313.077		
Steubens'	333.257		
Clyde	362.387		
Bath	422.687		
Chapmansville	575.927		

Stated Meeting, January 21, 1876.

Present, 15 members.

Vice-President, Mr. Fraley, in the Chair.

A photograph of Prof. Jas. C. Booth was received and ordered to be placed in the Album.

Letters of envoy were received from the R. Academy at Stockholm, and the R. Observatory at Greenwich.

Donations for the Library were received from the R. Academy at Stockholm, R. Academy and Observatory at Turin, Victoria Institute, Nature, Geological Society at Dublin, American Journal of Science, P. & L. Society at Leeds, Antiquarian Society at Albany, Academy of N. S. at Philadelphia, Franklin Institute, Medical Journal, Engineer

Department U. S. A., Congressional Library, Wisconsin Historical Society, and a Committee of the Boston Society of Civil Engineers.

Mr. Chase described a Japanese translation of Dr. Henry Hartshorne's book entitled, "Essentials of the Practice of Medicine."

Mr. Price exhibited a piece of wood, very dry and light, and not at all mineralized, recently obtained from a city well, and desired to place on record the following memorandum:

Two wells for drains have been dug at and near the southern end of the Hotel at the southwest corner of Broad and Walnut streets, the highest part of the old city of two square miles in area. After the surface and brick clay, the digging was through firm blue clay to the depth of thirteen feet from the curb line; then fine gravel; and at the bottom coarse "water gravel," which was penetrated to the depth of 27 feet from the curb, where the digging ceased, without going below that gravel. The lower was the coarsest, with pebbles two or three inches in diameter; and through it were scattered some unrounded stones, with angles more or less sharp, but only a few inches in length, and the largest not over eight inches long. Near the bottom was found the limb of a tree, two inches thick in the broadest diameter.

Mr. Blodget described the clays and gravels underlying the city, and a map of Broad street, from South street to League Island, which he had published to show that they were evenly deposited at about the level of tide.

Mr. Blodget said that, in the borings on League Island which he superintended, the gravel beneath the clay was proved to pass under the water and forms the river bed, affording good holding ground for ships everywhere, the central channel being 33 feet deep, and the inshore soundings 16 feet below low water mark. A little mud is seen at the upper end of the island. The southern end shows a tough clay, which sets or hardens on exposure, and is used for embanking. At Point Breeze, in excavations for the large bank, one foot of quicksand was found 45 feet down, under which lay firm gravel; the series from the surface downward being 1, top loam; 2, sandy clay and blue clay; 3, gravel. Piles 18 feet long driven through blue clay took firm hold in the lower gravel.

Mr Tathem said that at Fifth and Walnut streets there were two gravels, separated by 20 feet of blue clay and mud, a pure slimy blue clay without a particle of gravel.

Morris, Tasker & Co.'s well in Southwark went down 70 feet before striking rock, and continued in the rock to a depth of 250 feet.

Mr. Price said that his present excavations at Twenty-eighth and Oxford

streets, show at 15 feet from the surface a black streak 2 inches thick, the whole mass being gravel as far as they have yet gone.

Mr. Blodget recounted the experience of those who laid the foundations of the Masonic Temple, Broad and Filbert, where two gravels were found separated by 3 feet of quicksand, which required two powerful steam pumps 6″ and 8″ working night and day. The top of the quicksand layer was accidentally uncovered at the corner of the lot 40 feet deep, and this obliged the plan for laying the foundation to be entirely changed at an expense of say $30,000.

The great tower of the Public Buildings opposite to the Masonic Temple, has its foundation laid in the upper gravel, and there is a possibility of future disaster from the subjacent quicksand.

Dr. Cresson communicated also the following record and analyses of the boring at the Continental Hotel, at the corner of Chestnut and Ninth streets:

Analysis of Water from Artesian Well at Continental Hotel and Schuylkill River.

Analysis made by.....Charles M. Cresson, M.D., 417 Walnut Street.
Sample received.....March 22, 1875.
" amount of (U. S. G. = 231 Cubic Inches, = 8.332698)....4 gallons.
Analysis made.....March 23d—April 15th.

Condition of sample.....Small amount of Sediment.
Reaction.....Neutral.

Analysis No. 1442.			Artesian W. Grains in 1 U.S.Gallon	Schuylkill R. Grains in 1 U.S.Gallon
Sediment				
Solid matter upon evaporation to dryness			13.58000	6.99000
" " " " " after ignition				5.06000
Organic Matter (Carbonic Acid, &c.), by loss on ignition				1.93000
Silica		($Si O_3$)	2.11800	0.65000
Alumina		($Al_2 O_3$)	0.42800	0.05100
Oxide of Iron		($Fe_2 O_3$)		0.05900
Lime		(Ca O.)	1.47448	0.94640
Magnesia		(Mg O.)	0.46908	0.53280
Carbonic Acid		(CO_2)	not det.	not det.
Sulphuric acid	free	(SO_3)	none	none
" "	in combination		0.68750	1.18000
Chlorine	free	(Cl.)	none	none
"	in combination		0.65000	0.50000
Potash		(KO.)	chiefly potash.	chiefly soda.
Soda		(Na O.)		
Ammonia	free	(NH_3)	0.00646	0.00850
"	albumenoid		0.00442	0.02142
Nitrogen from Nitrates and Nitrites			0.18360	0.17000
Sewage			0.04420	0.21420

Well at Continental passed through,	Thickness of strata.	Total depth.
Sand and Gravel to Rock at	40 feet.	40 feet.
Blue Gneiss	100 "	140 "
Feldspar	1 "	141 "
Light Grey Gneiss	38 "	179 "
Pure Feldspar	27 "	206 "
Pump down to	178 "	384 "

Is a purer and better drinking water than that supplied from the Schuylkill, and equally good for household purposes. In March 1874 and 1875 water became muddy for four hours and then clear again.

Mr. C. E. Hall communicated, through the Secretary, a List of Genera and Species of Fossils determined by him during 1874 and 1875, to be included in his report on the Fossils of Pennsylvania for the Geological Survey.

Mr. Lesley communicated a list of 2,500 station-levels in Pennsylvania, collated from railway and other records, by Mr. Charles Allen, of the Geological Survey.

Mr. Chase communicated certain conclusions deducible from the curves of rainfall in North America.

Mr. Lesley was elected Librarian.

The following Standing Committees were appointed for the ensuing year:

Finance,

Mr. Frederick Fraley,
Mr. Eli K. Price,
Mr. Benjamin V. Marsh.

Publication,

Dr. John L. LeConte,
Dr. Daniel M. Brinton,
Dr. Harrison Allen,
Dr. Charles M. Cresson,
Mr. William M. Tilghman.

Hall,

Gen. Hector Tyndale,
Mr. Edward Hopper,
Mr. Solomon S. Roberts.

Library,

Dr. Benjamin H. Coates,
Mr. Eli K. Price,
Dr. Joseph Carson,
Dr. Charles T. Krauth,
Dr. George H. Horn.

Pending nominations 791, 792 were read.

Pending nomination No. 791 was balloted for.

The reading of the list of surviving members was postponed.

The annual report of the Trustees of the Building Fund was presented and referred.

On motion of Mr. Price, an appropriation of $500 was made for the immediate binding of the unbound Serials in the Library.

On motion of Mr. Blodget, it was

Resolved, That a Committee of this Society be appointed to consider the propriety of attempting a representation of the progress of research in Physical Science in the United States at the coming Centennial, and of inviting the co-operation of other Societies in such representations.

Mr. Blodget, Dr. Barker and Dr. Campbell were appointed the Committee.

On scrutiny of the ballot box by the presiding officer, it was announced that:

Dr. J. Gibbons Hunt was duly elected a member of the Society.

And the meeting was adjourned.

NEBULAR ACTION IN THE SOLAR SYSTEM.

By Pliny Earle Chase,

PROFESSOR OF PHILOSOPHY IN HAVERFORD COLLEGE.

(*Read before the American Philosophical Society, April 21st,* 1876.)

In studying the special evidences of nebular action, we find various significant relations, based on the following cardinal planetary positions, for which Stockwell's* values are taken:—

	Secular Perihelion	Mean Perihelion	Mean.	Mean Aphelion	Secular Aphelion	Secular Range
☿	.29743	.31873	.38710	.45546	.47677	.17934
♀	.67224	.69779	.72333	.74888	.77442	.10218
⊕	.93226	.98613	1.00000	1.03387	1.06774	.13547
♂	1.31105	1.40322	1.52369	1.64416	1.73633	.42528
⚳	4.88632	4.97824	5.20280	5.42735	5.51927	.63295
♄	8.73445	9.07764	9.53885	10.00006	10.34325	1.60880
♅	17.68803	18.32298	19.18358	20.04418	20.67913	2.99111
♆	29.59817	29.73221	30.03386	30.33551	30.46955	.87138

1. The minimum eccentricities of the principal planets, as found by Stockwell are:—Neptune, .00557; Uranus, .01176; Saturn, .01237; Jupiter, .0255; Earth and Venus, each, 0. The ratios, counting towards Sun, are, therefore, ♆ ÷ ♅ = 1 : 2.11; ♄ : ⚳ = 1 : 2.07. The closeness of these approximations to the fraction ½, suggests their probable dependence on a fall through a half-radius, which would give the particles of a nebulous ring the velocity of separation.

2. The secular ranges of the planets present many suggestive features. Jupiter's (.63295) corresponds with Earth's orbital radius of spherical gyration (.63245); Saturn's (1.6088), with the nucleal tendency of Earth's kinetic radius, $(1.4232^{\frac{1}{4}} = 1.6009)$; Uranus's (2.99111), with the asteroidal belt, and with a linear pendulum of which Earth occupies an oscillatory centre; Mars's, with the centre of linear oscillation of Jupiter's; Venus's, with the centre of explosive oscillation of Mercury's; the range sum of Neptune and Earth, (1.00685), with Earth's mean vector-radius; of Venus and Mercury, (.60462), with the kinetic atmosphere (.60087); the sum-ratio of Earth and Venus, (.23765), with the ratio of Mercury's greatest eccentricity (.23172).

3. Stockwell's estimates for the maximum secular eccentricity, Bessel's for the masses of Jupiter and Saturn, and Newcomb's for those of Uranus and Neptune, give the following values for the positions of centres of gravity, at secular perihelion, mean, and secular aphelion, the unit being Sun's radius:

*Smithsonian contributions, 232, pp. 37, 38.

	Perihelion.	Mean.	Aphelion.	Approximate Ratios.
⊙ ♅	1.0019	1.0668	1.1318	1
⊙ ♄	.5360	.5883	.6347	$\frac{1}{2}$
⊙ ♁	.1681	.1824	.1966	$\frac{1}{6}$
⊙ ♆	.3228	.3276	.3323	$\frac{1}{3}$

These values likewise exhibit a close approximation to the perihelion ratio $\frac{1}{2}$, between the companion planets of each pair, together with indications of nebular rupture between Saturn and Uranus, and of increasing condensation towards Neptune and Jupiter. The perihelion ratio of Neptune: Jupiter = 1 : 3.1; that of Uranus : Saturn = 1 : 3.2, or nearly that of a nodal division, to the entire length, of a linear pendulum. The reversal in the direction of condensation, between the central and the exterior belt, may perhaps explain the retrograde satellite motions of Uranus and Neptune.

4. If we compare the perihelion and the aphelion centres of gravity of companion planets, we find that .6347 is near the centre of spherical gyration $\left(\sqrt{.4} \times 1.0019 = .6336\right)$ of 1.0019, and that .1681 is near the centre of nebular rupture *(.1661) of .3323.

5. The time of revolution varying as $r^{\frac{3}{2}}$, while the time of rotation with the velocity due to interior *vis viva* varies as $r^{\frac{1}{2}}$, the limiting radius of synchronous rotation and revolution, for any given expanding or contracting nucleus, is a mean proportional between the limiting radii of interior and exterior nucleal rupture. I have shown that the gravitating impulses are $4565 \times (10)^{11}$ per second, corresponding in frequency with the red rays of light, and the modulus of light is

$$\left[\frac{365.256 \times 86400}{2\ \pi \times \sqrt{214.86} \times 497.825}\right]^2 = 473755 \text{ solar radii.}$$

If modulus were taken as the primitive radius of resisting inertia, $(r)^{\frac{3}{2}}$, Neptune's position would accord with the corresponding nucleal radius ($r = 6077.2$ solar radii), and Mercury's with the radius of internal rupture ($r^{\frac{1}{2}} = 77.96$ solar radii) Saturn's place being fixed, as we have seen, by the centre of nucleal planetary inertia, its *mean* aphelion radius appears to have influenced Neptune's position, while Earth's *secular* aphelion exerted a like influence on Mercury's position; for $1.04835 \times 6077.2 = 6371$, Neptunes secular perihelion being 6359.5, a difference of less than $\frac{1}{5}$ of one per cent.; $1.06774 \times 77.96 = 83.24$, Mercury's mean distance being 83.17, a difference of about $\frac{1}{12}$ of one per cent.

6. The mean proportional between these values of $r^{\frac{1}{2}}$ and r, as well as between Sun's radius and modulus, is 688.3 solar radii, or 3.203 times Earth's mean radius vector, which is near the outer limit of the asteroidal belt. This agrees very closely with the secular range of Uranus (2.99111), and the relation is still closer to the ratio between the gravitating radii of Saturn

*Velocity at $\frac{1}{2}\ r = \sqrt{2gr}$.

and Uranus $\left\{\frac{5883}{1824} = 3.209\right\}$. The positions of the principal masses in the three chief companion planetary pairs, indicate the same law of mean proportionality, between interior and exterior rupturing tendencies. For Jupiter's secular aphelion (5.5193) is at the geometrical mean (5.5195) between Earth's mean distance and Neptune's secular aphelion (30.46955). Neptune's secular perihelion (29.598) is within one per cent. of 6 × Jupiter's secular perihelion, or in inverse ratio of the indices in my equation of products of figurate powers, ($\Psi^1 \times \odot^3 \times \mathcal{U}^6 = \mathfrak{h}_2^{10}$).

7. The nodal influence of linear centres of oscillation, on material particles which are subjected to radial "lines of force," is shown in the vector-radii of the three outer planets, (Saturn, *mean aphelion*, 10; Uranus, *mean aphelion*, 20.044; Neptune, *mean*, 30.034). This tendency would be aided by the apparent primitive interposition of Sun between Jupiter and the exterior planets; for Saturn's vector-radius is so small, in comparison with modulus, that the above positions represent the geometrical progression, $(n + 1)$, $(n + 1)^2$, $(n + 1)^3$, as well as the arithmetical peudulum progression, 1, 2, 3, thus satisfying the requirements, both of elastic media and of simple force-lines. The many indications that Jupiter and Saturn were once parts of the same nebular belt, with a mean nodal difference* of 180°, serve to connect those accordances with the figurate equation.

8. As further clews to the significance of the figurate equation, it may be well to note the closeness of the accordance between the mass-ratios $\odot : \Psi$, $6\pi \odot : \mathcal{U}$, and the distance-ratio $(\mathcal{U} : \oplus)^6$; as well as Stockwell's ratios* of mean perihelion and node-motion.

9. The radial light oscillation which is synchronous with the present limit of possible circular revolution, is 10020.°25 ∔ 497.°825 = 20.128 Earth's vector-radii, which is also the rupturing radius of the retrograde-satellite and the direct-satellite planets, the difference between the secular aphelia of Saturn and Neptune, (or the vector-radius of Neptune relatively to the nebular planetary centre of inertia), being 20.126; the mean aphelion vector-radius of Uranus = 20.044; the major axis of the November meteors, and the secular aphelion of Uranus, each = 20.68; twice Saturn's secular aphelion = 20.69; the original nebular activity thus combining with the satellite influences, in maintaining Saturn's rings. Moreover, Neptune's secular perihelion = 1.4313 × the secular aphelion of Uranus, (the "kinetic radius" or the limiting radius of equality, towards which I have shown that *all* central forces mathematically tend, being 1.4232).

10. The sum of Uranus's mean, and Earth's secular perihelion vector-radius = 20.0158. The importance of Earth's position, the near approximation of this sum to the cardinal light oscillation (9), and the indications of a somewhat shorter major-axis for the inner meteors of the November stream, encourage us to look for still further evidences of continuing nebular activity, in our own orbit as well as in that of Saturn. If Earth and Uranus were once parts of an elliptical ring, or meteor current, with

* Stockwell, *op, cit*, p. xiv.

Earth sharing Uranus's present maximum secular eccentricity (.077965), Earth, Jupiter, Uranus, and Sun, were connected by the following equation:—Modulus $= 2\pi \times$ the square of Jupiter's mean radius vector $\times$ the time of revolution at secular perihelion (.922035) of a mean-proportionate radius between Earth and Sun $\left(1 : \sqrt{214.86}\right)^{\frac{3}{2}} \div$ (square of Earth's radius $\times$ 1 year). This value of modulus (474250) exceeds the value found by the ordinary methods (473755), by less than $\frac{1}{9}$ of one per cent.

11. The secular range of Uranus, between 17.688 and 20.679, subjects all the intra asteroidal planets, together with most of the asteroidal belt, to the influence of its accompanying light-oscillations, so that all the members of our interior system of dense planets may have been partially built up of materials from a meteoric stream, of which the November meteors are the *débris*. Earth's secular aphelion (1.0677; Cfr. the ratios of ♅ ⊙ centre of gravity, 1.0668, and of Jupiter's secular aphelion, 1.0608) was established near the linear centre of gravity of a pendulum, of which the kinetic radius marked the centre of oscillation ($\frac{1}{2} \times \frac{2}{3} \times 1.4232 = 1.0674$). Venus's secular perihelion (.6722), is near the centre of spherical gyration of Earths secular aphelion $\left(\sqrt{.4} \times 1.0677 = .6753\right)$.

12. If we take the primitive light-axis (20.128), and suppose it subjected to repeated oscillations through $\pm$ Earth's mean vector-radius, successive nodal bisections give the following approximations:

$20.128 - 1 = a$	19.128	Uranus.	19.184
$\frac{1}{2}\, a \quad = \beta$	9.564	Saturn.	9.538
$\frac{1}{2}\,(\beta + 1) = \gamma$	5.282	Jupiter.	5.203
$\frac{1}{2}\,(\gamma - 1) = \delta$	2.141	Asteroids.	
$\frac{1}{2}\,(\delta + 1) = \varepsilon$	1.571	Mars.	1.524

13. If the kinetic radius of Mercury's secular perihelion was also the radius of nucleal separation, its secular aphelion (102.438) was near a corresponding atmospheric radius ($1.4232^{\frac{1}{4}} \times 63.906 = 102.305$).

14. If the luminiferous, or kinetic æther is the permanent representative of the original hypothetical nebula, in which suns and planets are but floating particles, Faraday's "lines of force" may be due to longitudinal and transverse waves, either of various degrees of velocity but uniform frequency, or of various frequency but uniform velocity, or of velocities and frequencies both varying, in accordance with definite harmonic laws. The luminous, thermal, magnetic, gravitating, cohesive, and dissociating impulses,* all have simple harmonic representatives in the 26th musical octave, which is the special octave of light-proper; the gravitating impulses have also important harmonics in the 46th, 91st, and 92d octaves.

*The "selenium eye" illustrates one of these harmonics. Prof. W. G. Adams, (Proc. Roy. Soc. Jan. 6, 1876; P. Mag. April 1876) says: "the change in the resistance of Selenium is directly as the square root of the illuminating power." This is inversely as the velocity of nucleal rotation. The deflections in the dark (32) and in the strong sunlight (470) give the ratio 14.69; the ratio of emanating force at Sun, to that at Earth's orbit being 14.66.

15. Jupiter, the chief planet in the supra-asteroidal, and Earth, the chief planet in the intra-asteroidal belt, are connected by the following proportion. The number of light-oscillations (log. = 20.699916) which would communicate the greatest gravitating velocity in our system ($\sqrt{2gr}$ at Sun) : the number (log. = 15.822542) in describing Sun's circumference ($2\pi r$) : : velocity of revolution at earth ($1 + \sqrt{214.86}$) : velocity of gravitating fall at Jupiter $(1 + 1051.298)^2$, the units of velocity being taken, respectively, at Sun's surface, and at the limit of equilibrium between $\odot$ 2 aggregation or dissociation (1.4232 + 1049.875).

16. The same chief planets are also connected by the proportion : — $\sqrt{\text{Modulus}}$ (688.3) : light-producing wave at the mean-perihelion centre of gravity of Sun and Jupiter ($\pi \times 1.0198$) : : Earth's mean radius vector: Sun's radius. The value of Earth's radius-vector thus found, is 214.842; the value which is derived from the observations which I have thought the most accurate, being 214.86.

17. Jupiter and Sun thus appear to be companion constituents of a binary star, and the point of primitive rupture should be sought at the secular perihelion centre of gravity. Bodies falling toward that point, or approaching Sun, are subject to a force of about 1048 towards Sun, and 1049 towards the slowly moving common centre of gravity. There are, therefore, two nodal points, with the least resistance to motion nearly midway $\left(\frac{1048}{2097}\right)$ between them. If Sun is gaseous, as Hunt, Faye, and others have supposed, there should hence arise linear oscillations of $2 \times 2r$, synchronous with the circular oscillations of $2\pi r$. The corona may, perhaps, be due to such radial oscillations.

18. The 15th accordance gives for the mass of Sun ÷ Jupiter, 1049.875 — 2 = 1047.875; the 17th, 1049.874 — 2 = 1047.874; Bessel's estimate being 1047.879 ± .235.

19. The discrepancy between the two astronomical estimates for the velocity of light, seems to have arisen from ignorance of the internodal oscillation. Delambre, from his discussion of more than 1000 eclipses of Jupiter's first satellite,* estimated the time of light-passage from Sun to Earth at 493,^{s}198; Struve, from the phenomena of aberration, at 497.^{s}827. If the time of traversing 212.86 solar radii is 493.198, the time for 214.86 r should be 497.831, which differs from Struve's value by less than $\frac{1}{1000}$ of one per cent.

20. If Earth was at the nebular nucleal *surface*, when the Jovi-Saturnian ring was nebularly atmospheric, the *vis viva* of interior nucleal rotation varied as r; and the velocity of resulting planetary revolution, as $r^{\frac{1}{2}}$. We thus obtain, for the theoretical time of present solar rotation, $\sqrt{214.86} : 1 : : 365.^d256 : 24.^d912$. The lowest estimate from observation is Spörer's 24.624; the highest, that of Schwabe, 25.507.

*Stockwell, *Proc. Amer. Asso.* XX. 76-7.

21. The laws of central forces require that provision should be made for radial oscillations, tending towards the time-limit of iso-radial circular oscillations ($\sqrt{32}$ and $\sqrt{8}$); for tangential velocities, varying inversely as the times and directly as the fourth root of central iso-radial *tendencies;* for centres of oscillation in lines of force, and for oscillations between systematic and locally dominant centres. We have already seen (15, 17, 18,) how closely the relative masses of Sun and Jupiter provide for the last requirement; if they provide also for the others, the centre of oscillation for Sun's possible atmosphere should be at $1047.875 - (\sqrt{32})^4 = 23.875$ solar radii. The corresponding height of possible atmosphere, or the height of equality between the velocities of rotation and revolution, is $\frac{3}{4}$ of 23.875 $= 35.813\ r$. This would give, for the time of solar rotation, $365.256 \div (214.86 \div 35.813)^{\frac{3}{2}} = 24^d.856$, differing less than $\frac{1}{4}$ of one per cent. from the *vis viva* estimate (20).

22. The ratio $1 : 32^2$ is also simply connected with the mass and distance of Jupiter's companion planet, Saturn, and so with the centre of planetary inertia. For $1024 + 1025 + .536 = 2049.54$ (3,17), Saturn's mean radius vector being 2049.51 solar radii; $1024 + (35.813 \div \sqrt{.4}) = 1080.625$ is the limit, of which Jupiter represents a centre of explosive oscillation, and the inertial moment at the limit gives the mass of Sun ÷ Saturn; for $1080.625 \times (\frac{2}{3})^2 = 3501.2$, Bessel's value being 3501.6.

23. Among the many harmonies of planetary mass which manifest a dependence on nebular influences, the following are, perhaps, indicative of some of the earliest forms of activity.

a. The masses of Jupiter and Earth are nearly proportionate to the squares of their periodic times × the velocities due to internucleal *vis viva;* $5.2028^3 \times 5.2028^{\frac{1}{2}} = 321.2$; $321.2 \times 1047.875 = 336201$.

b. The influence of *spherical* gyration on Venus (11), seems to be further shown by its ratio to Earth, which is the *square* of the ratio of Uranus to Neptune $(\sqrt{8} : \pi) : \pi^2 \times 336201 \div 8 = 415289$. Hill's estimate of the mass of Sun ÷ Venus is 408134. If the internucleal *vis viva* of Jupiter were taken at secular perihelion, the resulting theoretical mass-denominators would be Earth, 326222; Venus 402460.

24. The masses of the principal planets, therefore, seem to have been primitively determined by the following influences:—Neptune, by the proportion between the time of direct fall to the centre of planetary inertia, and the time of circular revolution; Uranus by the time of describing the same proportional part of a circle, in the circular orbit; Saturn, by equality of nebular *vis viva* with Jupiter, when the two centres of condensation were in opposite parts of the nebular belt and on opposite sides of the sun; Jupiter, by the ratio of variability, between incipient fall to a centre of linear atmospheric oscillation and circular revolution; Earth, by the combined action of *vis viva* and time of revolution; Venus, by the action,

in a spherical mass, of the same force as determined Uranus in a circular disc. The mass-denominators are,

	Theoretical.	Observed.	Authority.
♅ $32^2 + 23.875$	1047.875	1047.879	Bessel.
♄ $\left[\frac{9.539}{5.203}\right]^2 \times$ ♅	3522.3	3501.6	Bessel.
♆ $\sqrt{32} \times$ ♄	19925.3	19700	Newcomb.
♇ $\pi \times$ ♆ $\div \sqrt{8}$	22133.4	22600	Newcomb.
⊕ $5.203^3 \times 4.886^{\frac{1}{2}} \times$ ♅	326222	322800	Newcomb.
♀ $\pi^2 \times$ ⊕ $\div 8$	402460	408134	Hill.

25. These masses, with Hansen and Olufsen's mass for Mars, and Encke's for Mercury, give the following ratios for the extra and intra asteroidal groups :—

	Theoretical.	Observed.		Theoretical.	Observed.
♅	1.0000	1.0000	⊕	1.0000	1.0000
♄	.2975	.2993	♀	.8106	.7909
♆	.0526	.0532	♂	.1019	.1009
♇	.0473	.0464	☿	.0670	.0663
	1.3974	1.3989		1.9795	1.9581

Here is a further approximation, in the inner system, to the square of the outer ratio, accompanied by suggestive indications of the influence of the ratio between aggregating and dissociating velocities $(1 : \sqrt{2})$, and of the ratio between the oscillatory and kinetic radii (1.4232 : 2 : : 1 ; 1.405). The outer is about 220 × the inner, or nearly as Earth's radius-vector is to Sun's radius.

26. To the primitive influences others were subsequently added, depending upon mutual actions and reactions, some of which have already been pointed out, and others are obscurely intimated by harmonies which can hardly be regarded as accidental. To this latter class the following may be added:—

a. Jupiter's mass is to Neptune's mass, as $\pi \times$ Neptune's radius vector is to Jupiter's radius vector; Neptune's mass is to Earth's mass, as $\pi \times$ Jupiter's radius vector is to Earth's radius vector.

b. The mass of the intra-asteroidal planets : Sun's mass : : square of Jupiter's secular aphelion : square of light-modulus.

c. The limit of possible solar atmosphere : $6^2 \times$ Sun's radius : : Earth's polar: Earth's equatorial diameter. ($6 = 2 \times 3 =$ product of number of gravity nodal divisions by number of oscillatory nodal divisions in a linear pendulum; Cfr. Jupiter's mass $= 6\pi \times$ Neptune's mass).

27. Struve estimated Sun's proper motion at 1.623 × Earth's radius vector per annum, which is .258 times Earth's orbital motion, the motions being, therefore, in the ratio of their densities.

28. If we add the orbital motions of Earth and Jupiter, to Sun's proper

motion, we obtain, in units of Earth's mean radius vector, Earth, 1.258; Jupiter, .6964. Jupiter's proper motion is, therefore, that which is due the "centre of explosive oscillation," ($\frac{5}{9}$), of which Earth is a limit.

These accordances furnish new data for approximating to the primitive parabolic abscissas of interstellar action. For if we take the kinetic radius

$\left.\begin{array}{l}\dfrac{2\ \pi^2\ r}{\pi^2+4} = 1.4232\ r = \text{radius of } \textit{mean} \text{ velocity of radial, synchronous with} \\ \text{with circular, oscillation}\end{array}\right\}$ and the solar modulus limit of possible atmosphere, (35.813 × radius) as determinants, the three known abscissas (ξ; $\xi + \eta + \zeta$; $\xi + 27\,\eta + 729\,\xi$) give the following logarithms for planetary and stellar abscissas:

			Theoretical.	Perihelion.	Mean.	Aphelion.
ξ = solar radius			.000000		.000000	
$\xi + \eta + \zeta = 1.4232^{\frac{3}{4}}$*			.114950		.114950	
$\frac{3}{4}$ ☿	log.	$\xi + 10\,\eta + 100\,\zeta$	= 1.678467	1.680602	1.795038	1.885522
$\frac{1}{2}$ ♀	"	$\xi + 11\,\eta + 121\,\zeta$	= 1.910966	1.858650	1.890463	1.920003
$\frac{3}{5}$ ⊕	"	$\xi + 12\,\eta + 144\,\zeta$	= 2.155219	2.125604	2.156064	2.184527
$\frac{3}{4}$ ♂	"	$\xi + 13\,\eta + 169\,\zeta$	= 2.411227	2.324836	2.390112	2.446847
$\frac{4}{5}$ Asteroid	"	$\xi + 14\,\eta + 196\,\zeta$	= 2.678989			
$\frac{4}{6}$ ♃	"	$\xi + 15\,\eta + 225\,\zeta$	= 2.958507	2.941956	2.969211	2.994855
$\frac{4}{7}$ ♄	"	$\xi + 16\,\eta + 256\,\zeta$	= 3.249779	3.206444	3.244704	3.279865
$\frac{7}{8}$ ♅	"	$\xi + 17\,\eta + 289\,\zeta$	= 3.552807	3.521682	3.557093	3.589694
$\frac{4}{5}$ ♆	"	$\xi + 18\,\eta + 324\,\zeta$	= 3.867589	3.861415	3.867758	3.873951
35.813 M†	"	$\xi + 27\,\eta + 729\,\zeta$	= 7.229595		7.229595	
a Centauri‡	"	$\xi + 28\,\eta + 784\,\zeta$	= 7.661925	7.657096		7.686009

We have seen (5) that the limits of the planetary system (Mercury and Neptune), were fixed by the radius of internal rupture and the nucleal radius which correspond to the modulus of light. The values $\frac{1}{2}$, $\frac{2}{3}$, $\frac{3}{4}$, &c., represent the points at which particles falling from $1r$, $2r$, $3r$, &c., would acquire the velocity of central disintegration ($\sqrt{2gr}$). The like co-efficients of Mercury and Mars ($\frac{3}{4}$) seem to indicate satellite relations to Earth and Venus; all the abscissas between Mercury and Neptune, are within the range of orbital eccentricities, the greatest deviations of the theoretical from the mean values being those of Venus and Mars, which are less than five

* The nucleal radius varying as the $\frac{3}{4}$ power of the atmospheric radius. Compare Alexander's ratio for exterior half-planets (*Smithsonian Contributions*, 280, *p.* 5.)

† Modulus, or the double height of virtual fall which would give the velocity of light, bearing the same ratio to the modular atmosphere, as solar radius bears to solar atmosphere.

‡ The least value is given by Norton; the greatest by Denison. There is no reason for doubting that the true value is between the two.

per cent. Jupiter's deviation is about 2.6 per cent.; Saturn's, 1.2 per cent.; Uranus's, 1 per cent.; Earth's, $\frac{1}{5}$ of 1 per cent. The co-efficient-products in the three principal planetary pairs are, ♀ ⊕, $\frac{1}{2} \times \frac{3}{3} = \frac{1}{3}$ = nodal division of linear pendulum; ♃ ♄, $\frac{2}{5} \times \frac{5}{7} = \frac{2}{7}$, nearly = 2 $r \div$ kinetic radius; ☉ Ψ, $\frac{7}{8} \times \frac{8}{7} = 1$. It seems probable that the actual determining orbit was an ellipse, the two foci being within the masses of Sun and *a Centauri*, but the difference between parabolic and elliptical co-ordinates in our planetary system, is not recognizable so near the focus.

Improved Mounted Burettes for Volumetric Analysis.

By J. Blodget Britton.

(*Abstract of remarks made before the American Philosophical Society, December 3d*, 1875.)

More than a year ago (meeting of November 20th, 1874, Vol. XIV, No. 93, p. 189, of the published proceedings) I exhibited several burettes mounted on stands, and delicately graduated for close, volumetric analysis, differing from each other, but each having the screw and spring valve adjustment, and also one of the rod-stoppered kind, having the screw and top spring lever adjustment.

I now exhibit and shall explain three others also mounted, and delicately graduated, yet still more improved.

The shortest one (Fig. 1 in the annexed plate), has a capacity of 100 cc, with its scale divided into tenths, or one thousand degrees. The glass rod inside of the tube is operated by means of a thumb-screw (A) which works against a horizontal lever (B) under the stand. The lower end of the light vertical iron rod (C) inside of the wooden upright of the stand, rests upon the front of the lever, and its upper end encircles the glass rod directly under its knob. By turning the thumb-screw, the iron rod, and with it the glass one, may be raised or lowered, and the vent of the burette opened or closed at pleasure. The flow may thus be completely controlled or instantly stopped.

The second instrument (Fig. 2 in the plate) is between four and five feet long, and has a capacity of 240 cc, with its scale divided into tenths or two thousand four hundred degrees. It is operated with the thumb-screw (A) like the shorter instrument from which it differs in construction only in the position of the screw and lever and shape of the latter. The screw is placed

Fig.1.

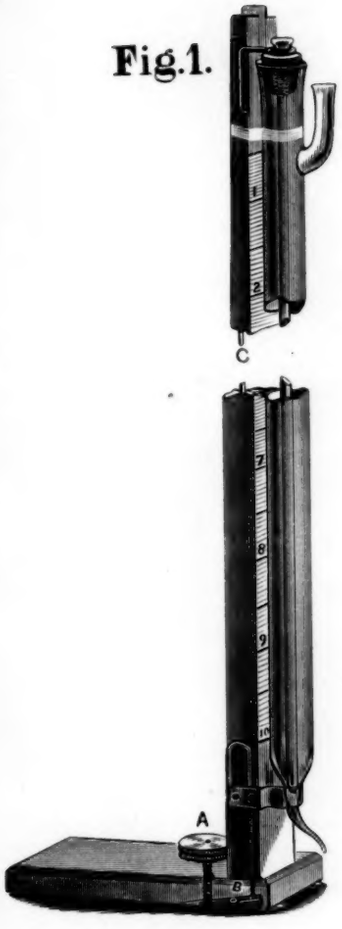


Fig.2.

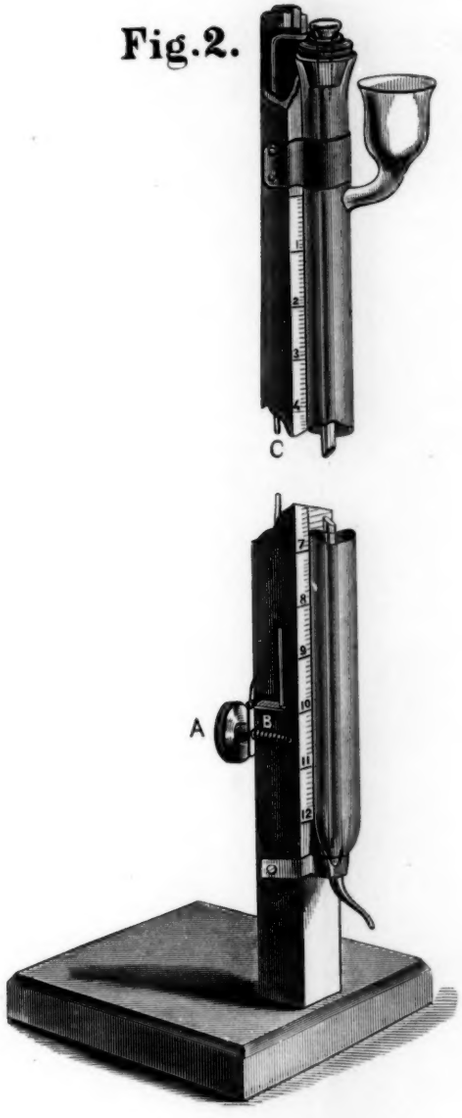


Fig.3.

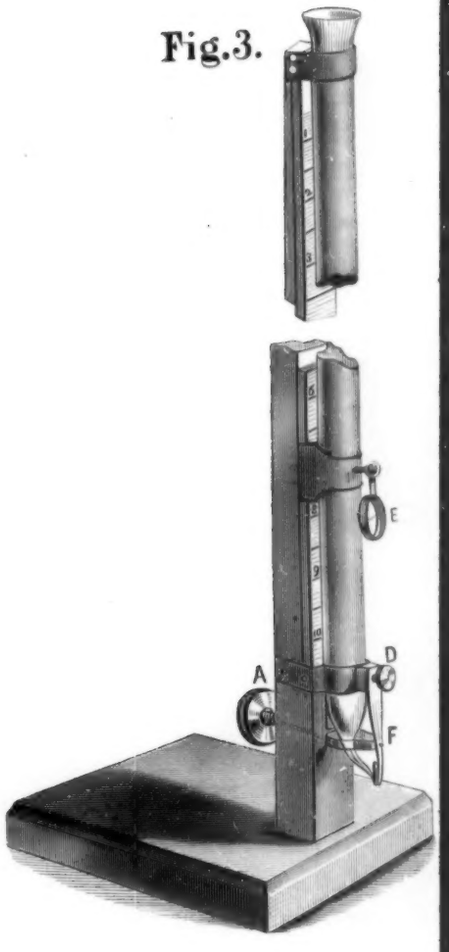
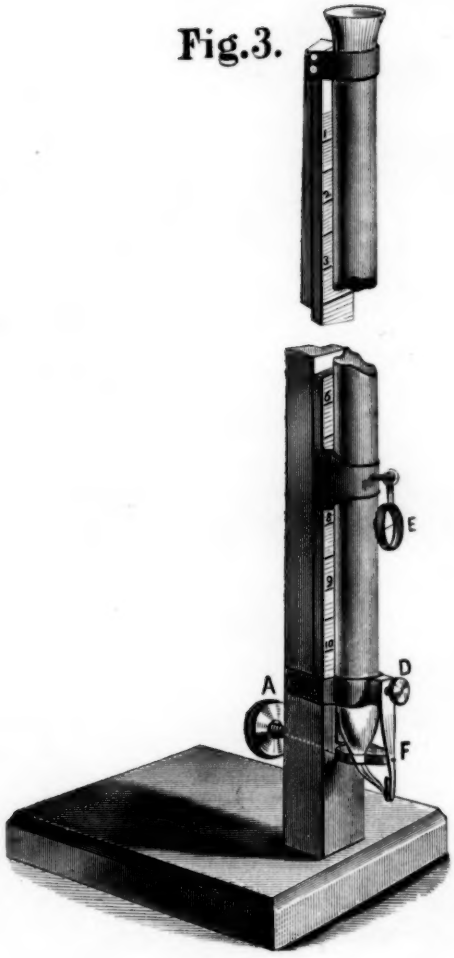


Fig.3.



high up on the upright to allow it to be conveniently grasped when the instrument is being adjusted for use. The eye must at that time be raised to a level with the 0 point of the scale to watch the fluid fall gradually to exactly that point. Should the screw be more than about thirty-four inches below, the hand could not reach it to make the adjustment, its position must therefore depend upon that of the 0 point or length of the instrument.

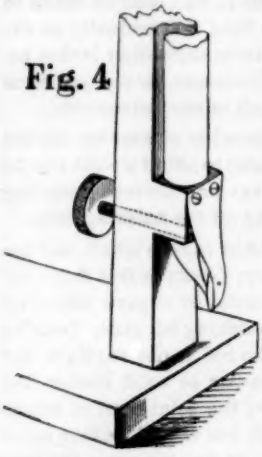
A short burette should have its thumb-screw placed at or near the bottom of the stand (as shown by Figs. 1 and 3 in the plate) to afford a solid rest for the hand while operating; such a rest will prevent any nervous trembling of the thumb and finger when cautiously shutting off the finishing drop.

When it becomes necessary to use a strong acid or caustic alkali, and the analytical work is to be done with great accuracy, I believe that these burettes will give full satisfaction. There is no metal or organic substance about them with which the fluid can be affected—nothing but glass. Leaking to any annoying degree does not occur when the rod is not too light and care is taken to exclude from the tube any granular or solid matter that would prevent the rod from shutting down close; the joint must of course be properly ground, and the opening not too large; but should leaking occur regrinding may be done in two or three minutes by dropping into the tube a few grains of emery flour with some water, and then turning the rod sharply round and round, alternately lifting and pressing it a little. It is best, however, not to neglect to make a note of the reading for any length of time after it can be done correctly. The long instrument will be found very serviceable in a laboratory where many consecutive determinations are to be frequently made, for one filling will answer for several, though it is rather cumbersome for only occasional work, and ordinarily the short one will be preferred. They are exhibited together to illustrate the two ways of placing the thumb-screw and lever.

The third instrument (Fig. 3 in the plate) is of the kind I have had in use for about ten years, and with which a great many thousand iron determinations have been made, always working very satisfactorily. Two of them of different patterns were described in the *Journal of the Franklin Institute* for May 1870, and in the London *Chemical News* for July 5th, of same year. The one now exhibited has a capacity of 100 cc, with a delicate graduation, and is about forty-three inches long, the thumb-screw being nearly thirty-three inches from the 0 point of the scale, and near enough to the bottom of the stand to afford a rest for the hand. It has two improvements, one of which is an adjustable plano- convex lens (E) secured by movable joints to a light, metallic frame. The frame is made to slide up and down easily in grooves on the sides of the upright, and has on its right side a vernier. This arrangement permits the scale to be read with extreme precision, and when not required as in ordinary technical work, it may be slid entirely off, and laid aside. The other improvement, which is a minor one, consists of a single, small thumb screw (D) to hold the spring valve (F) in place, while at the same time it allows the valve to be taken off very conveniently when necessary to remove any matter choking the vent,

and afterwards to be as conveniently replaced. The old arrangement (Fig. 4) required two screws, for the removal of which a screw driver was necessary. I, however, have not adopted the new to the complete expulsion of the old, which costs but a trifle, and in some respects is excellent.

Fig. 4



NOTES. Each of these burettes, it will be observed, has its graduated scale on white paper firmly pasted against the upright and behind the tube, and not cut on the tube itself; the graduation consequently is as distinct as it is possible to make it, and the reading being *over* the fluid, which affords a *level* to guide the eye, is done with the least liability to error. In this manner the finest of my burettes have been made. When the cutting is on the tube, I prefer it to be behind, and not in front, and well rubbed with lampblack and oil, and have a white paper pasted on the upright for a ground to make it more plainly seen.

Each tube has its lower end drawn out small enough to just allow a stout hog-bristle to pass freely in and out of the vent, and in order that the discharge may be made sufficiently far over into the receiving vessel, it is bent outwards with the point downwards, so that the vent shall be an inch and a half from the upright, and three inches from the bottom of the stand. The rod-stoppered tubes have their points made smooth by fusion, but the spring valved have theirs carefully ground on an emery plate to allow the valves to shut quite true and tight with the line of contact just vertical, and not at an angle.

Unnecessary thickness of glass about the points is avoided, and the valves are made small, especially at their lower ends, to give as little surface of material as possible for the retention by capillary attraction of the dropping fluid. To further obviate such retention, my practice is to occasionally rub the points and valves with a little pure tallow, the effect of which is excellent. Burettes made in the manner described, may with their valves wide open be discharged of 100 cc in about two minutes. But when there is a rapid discharge, a considerable quantity of the fluid is held back on the walls of the tube by attraction, and the quantity so held becomes increased with increased rapidity of discharge; this is shown most distinctly when a strong solution of chameleon is used, for the material gives color to the tube so long as any of it remains. A rapid discharge consequently will not permit a prompt reading, and if the tube be long some minutes must elapse before all of a fluid, of any considerable density, reaches the bottom. The case, however, is different when the discharge is moderately slow and uniform; the reading may then be done usually soon after the reaction has

been effected. Against hasty work, therefore, beginners should be specially cautioned, and a slow discharging instrument would be best in their hands

I have experimented in years past, as stated at a former meeting, with valves made of quite a number of substances, hard and soft. Of the hard sort, glass when ground true and cushioned behind, afforded a tighter joint than metal, and gave altogether the most satisfaction, but still with ordinary every day usage would not keep in order, and withstand the pressure of a full column of fluid without leaking more or less. Of the soft sort, rubber and fine grained cork were the best; the latter proved most excellent when solutions of potassium permangenate and bichromate were used. for, while always giving a perfectly tight joint, and being sufficiently durable, it became *absolutely inert, and never got sticky from applications of tallow* like rubber. Cork has been in use at the Iron-Masters' Laboratory constantly since 1866, and I still prefer it for my purposes; when cut perfectly true and rubbed with tallow, it will make a valve from which globules no larger than the head of an ordinary pin can be discharged at will. I attach it to the spring with a rivet, and sometimes with a cement; for attaching thin rubber I have used a cement and also a benzine solution of rubber. For springs I have used platinum, brass, steel, and common tin plate.

Of the instruments exhibited, the rod-stoppered kind have the advantage of universal application, but the spring valved kind have more solidity and compactness, and will bear much rougher usage.

The one described by George A. Kœnig, Ph. D (Vol. XIV, No. 93, p. 218, of the published proceedings) is the short, graduated tube furnished by the dealers. to which is fitted the thumb-screw, and spring valve adjustment, the screw working through the spring, and not against it. It is not permanently mounted, and must be used like the one long ago proposed by Mohr (See side view Fig. 5). He states that by putting a hinged joint to the spring he has been enabled to use a platinum valve with a 30 cc tube, the delicacy of the hinge though, was found to be an objection, making the valve liable to get out of order. He further states that a spring coated with rubber will resist the action of standard acids. The instrument is substantially what had been produced years before, and, as must be obvious, is not so perfect as the permanently mounted one.

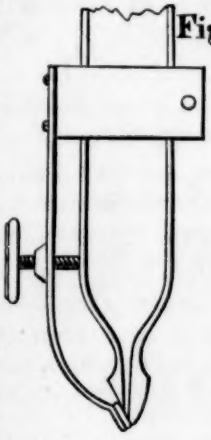


Fig. 5

Stated Meeting, February 4th, 1876.

Present, 17 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters of envoy were received from the Botanical Gardens, at St. Petersburg, December 19th, 1875, and from the Albany Institute, January 28th, 1876.

Letters of acknowledgment were received from the New Bedford Public Library, 93,94; New York Historical Society, 95; and Rantoul Literary Society.

Donations for the Library were received from the Asiatic Society, Japan Branch; R. Academy, at Brussels; Royal Astronomical Society, in London; London Nature; Peabody Academy at Salem; Boston Society of N. H.; Mr. Edmund Quincy; American Journal of Science, and Professor Marsh, of New Haven; Albany Institute; Society of N. S. Buffalo; American Pharmaceutical Association; A. Journal of Pharmacy; Penn Monthly; Medical News; Social Science Association at Philadelphia; and U. S. Department Interior.

The death of John C. Cresson, first Vice-President of the Society, was announced by Mr. Eli K. Price, as having taken place January 27th ult., aged 69 (born March 16th, 1807).

On motion of Mr. Price, Mr. Fraley was appointed to prepare an obituary notice of the deceased.

Prof. Hart made a statement of the arguments for and against the genuineness of the "Death Mask of Shakespeare" said to have been discovered in Germany, illustrating his remarks by photographs of the principal portraits of Shakespeare, and of the mask in different positions.

Mr. Chase made reference to the paper of Dr. D. Ast, in the American Journal of Science and Arts for January, 1854, reproduced in the American Chemist for May, 1875, on observations on the spectra of metals in the electric circuit.

Pending nomination No. 792 was read.

Mr. Fraley reported the receipt of $150.40, the dividend from the Michaux legacy last due, January 1st, 1876.

Mr. Blodget, on behalf of the Committee appointed at the last meeting, made a preliminary report, and the meeting was adjourned.

Stated Meeting, February 18th, 1876.

Present, 13 members.

Vice-President, Mr. FRALEY, in the Chair.

A letter accepting membership was received from Dr. J. Gibbons Hunt, dated Philadelphia, February 4th, 1876.

A letter respecting the action of the Society on the subject of the Polaris Expedition was received from Admiral Davis, dated Washington, February 15th, 1876.

A letter respecting a coin of 1670, the date of the settlement of Quebec, struck by order of Louis XIV, and making the first currency of French North America, was received from Prof. Charles E. Anthon, dated, College of the City of New York, February 11th, 1876, desiring to learn whether the Society would accept the coin, and place a record of its character in their Proceedings.

A letter of envoy was received from the U. S. Naval Observatory at Washington.

Letters of acknowledgment were received from the R. Danish Academy, January 15th (XVII. 93, 94); Essex Institution, February 5th (95); Boston N. H. S. (95; and asking for Vol.V, N. S. and 94); and the U. S. Naval Observatory, February 4th (95).

Donations for the Library were received from the Society at Dresden; the Geographical Society at Paris; the Editors of the Revue Politique; Nouvelles Météorologiques; Revue Philosophique; and Revue Historique; the British Association; Geological, and Meteorological Societies; Nature; Mr. Sam. Birch of the British Museum; Liverpool L. and P. Society; Franklin Institute; Medical News; Prof. E. J. Houston; and U. S. Naval Observatory.

The Committee on Dr. Valentini's memoir was continued.

The death of Mr. Charles des Moulins, at Bordeaux, on the 23d December, 1875, was announced by letter.

Mr. Blasius read a defense of his theory of storms.

A Brief Discussion of Some Opinions in Meteorology.

By W. Blasius.

Read before the American Philosophical Society, February 18th, 1876.

The definite establishment of the laws which regulate the weather is of so much general importance that I am induced to ask your attention to the following remarks, since the discussion of opinions cannot fail to elaborate the truth at last.

In the January number of the Atlantic Monthly, there appeared a fair-tempered review of my recent work on "Storms," which seems to be from the pen of a practical meteorologist, between whom and myself, therefore, I am the more anxious that there should be no misunderstandings. The reviewer does not deny nor admit the truth of the theories I have advanced, but leaves them to the verdict of time.

He in some important particulars, however, fails to understand the views I hold. Permit me to quote:

"The West Cambridge Tornado, which first decided the direction of our author's meteorological studies, seems to have had a too powerful influence upon his judgment of the 'cyclonists,' the upholders of Redfield's Theory. Where a cyclonist sees a large storm 500 miles in diameter, on the borders of which the winds are blowing in every direction, Dr. Blasius sees many small storms, each modeled in a greater or less degree like the West Cambridge Tornado. A very striking proof that a storm may be constituted as the cyclones are supposed to be is afforded by the singular case of the ship Charles Heddle, which was caught in the borders of one of these cyclones, and sailed five times completely around its border, meeting winds blowing exactly in the directions demanded by the cyclone theory. The experience of Dr. Blasius has been limited to local storms, and he has apparently never been able to realize the existence of a storm of any magnitude.

This is particularly evident in the discussion of Prof. Abbe's report on the Nova Scotia storm of August 23, 1873. Prof. Abbe is speaking of a storm at least 500 miles in diameter, but Dr. Blasius discusses it as if it were an assemblage of tornadoes each 1,200 feet wide."

Now the statement that where "a cyclonist sees large storms," I see "many small storms" is curious enough, since a considerable part of my

book is devoted to an attempt to prove that in many cases where the U. S. Signal Service and other cyclonists see "many small storms," each independent of the other, there is in reality one large storm hundreds of miles in width.

And as for the fact that "a storm may be constituted as the cyclones are supposed to be," the position I have taken is not that there are *no* cyclones, but that there are none in our latitude, and that the theory which would make all storms cyclones is radically erroneous. The citation of the Charles Heddle case, to which I have also alluded in my book, is not a very fortunate one, however, since it is far from being authentic. Even Dove himself, the great apostle of the cyclonic theory, calls it a "sea romance," "oder auf gut muselmænnisch gesprochen, etwas was gesehehen sein kœnne, wenn es dem Propheten so gefallen hætte."

Even if it were authentic, however, it would not conflict with any position I have taken, since the storm to which it relates was a typhoon of the Indian Ocean.

The complaint that my experience has been limited to local storms, shows some confusion of ideas, since it is not to be supposed that extensive storms have avoided me, or that the researches of others are not open to me. The reviewer in another place says:

"If Dr. Blasius's book were not dated from the Atlantic coast, the meteorologist could yet determine quite accurately his latitude and longitude from the types of storms he gives."

This is quite satisfactory, since the professed aim of my book is to give general principles, capable of universal application, and then to show how these principles are applied to our latitude as example of the modifying effect of differing local circumstances. Meteorology is largely a science of locality, after all, as well as of the air; mountains, lakes, forests, the sea—all have their effect in determining how the general weather changes will affect us. And this is the reason why predictions for a large section of country, such as the signal service give can never be so accurate as to be of much use.

That I have endeavored to show how general principles could be locally applied, probably affords the Atlantic Monthly reviewer ground for supposing my views restricted; but he cannot have read the book very carefully. So far from not being able "to realize the existence of a storm of any magnitude," it is one of the main points of difference between the cyclonists and myself that, whereas they consider the area of low barometer *the* storm, my views make this but a part of the storm, which covers also much larger areas of high barometer in front and rear.

The particular case cited, that of the Nova Scotia storm of August 23, 1873, is not at all to the point, since, instead of taking a more limited view of the phenomenon than Professor Abbe does, I hold that the storm was twice as large as Prof. Abbe supposes it to have been, and that one-half of it the Signal Service never knew at all. More than this, the half they did not see was that which was on land within their jurisdiction, and was the real

cause of most of the tremendous destruction that occurred. The Signal Service maps of this storm merely note an "area of high barometer" coming from Manitoba on the 22d, to which they attach no significance, and which they do not connect with the Nova Scotia storm; but I feel convinced that this very same "area of high barometer" really an advance of heavy air from the North, was responsible for the loss of most of the thousand and odd vessels that were destroyed on the coast. If the Signal Service had only known its true character, they would have been able to give, at least a day ahead, forewarnings of this most terrible storm which, as it was, took them entirely unawares.

In these "areas of high barometer" the cyclonists see an inexplicable something which they call an "anti-cyclone;" in which they think the air rotates in the opposite direction from that in a cyclone, and that it brings dry and fair weather. The celebrated Le Verrier, acting on this theory, on account of the advance of such an "area of high barometer" over England, predicted fair weather just before those violent storms and terrible floods which last Summer desolated so large a tract of country in France. The theory which I hold would have shown him in this "area of high barometer" an advance of the polar current, almost certain in the Summer season to produce violent rains. It was much the same case with the Nova Scotia storm.

As for the statement that I have discussed this storm as if it were "an assemblage of tornadoes," (*sic*) I do not see any evidence of a tornado at all. A tornado is only a local incident—although a terrible one—in the passage of a Southeast storm, caused principally by the configuration of the ground, notwithstanding that the Signal Service describes one as "at least thirty miles," and "probably 240 miles" in diameter.

The Atlantic reviewer states that, "as a matter of fact, the Signal Service notes all storms within the limits of the Atlantic coast and the Rocky Mountains," and "its object is to obtain the laws of them as they exist." In my book I have pointed out several instances where the advance of the polar current, producing a Southeast storm of considerable magnitude is treated by the Signal Service as a series of detached local storms, such as tornadoes, hail-storms, cloud-bursts, etc., of which they know nothing until they are over; cases of this kind are abundant in the Signal Service reports. If the object of the Signal Service is to establish laws, why—I ask it in no hostile spirit—has it as yet given no laws to science? Or why does it, as the New York *Nation* lately says, "Keep as widely as possible aloof from the science of the country?"

I have also protested against the practice of observing only at fixed hours of the day, contending that if an individual storm is to be known, it must be observed continuously so long as it lasts. The Atlantic reviewer thinks it is not necessary for the Signal Service to do this, because "these (continuous observations) are easily accessible in the quarterly reports of the meteorological office of England!" Upon this method, if you wish to know what are the distinctive characteristics of an African elephant, all you have

to do is to get some one's description of an Asiatic elephant, and draw your own conclusions. Mr. F. Gaster, of the London Meteorological Office says upon this point, that at Valentia, where observations are not made between the hours of 8 A. M. and 2 P. M. "Storms have been overlooked, which would doubtless have been noticed at the Central Office, where the weather is observed continuously." Is it not at the least very probable that the Signal Service, making but tri-daily observations, has overlooked storms in the same way?

In my book I urge that observations of the clouds *in connection* with ærial currents is of the greatest importance, which the Atlantic Monthly writer attempts to meet by saying that the Signal Service has made tri-daily maps of the clouds for four years. This may be true, but it has never made observations of the intimate connection of the clouds with ærial currents, nor understood this significances. Early in 1874 I explained my views to Prof. Henry of the Smithsonian Institute, in a personal interview, and he then said, "This is all new to me." He took copious notes. The Signal Service report for 1873, published after this, contains a few old plates of the cloudforms given by Howard, Pœy, and others, but with no reference to them in the text. That of 1874 contains cloud maps for one day, with no reference in the text, and contains no attempt to give the particular forms any distinctive character. The eminent meteorologist, Prof. H. Mohn, Director of the Royal Meteorological Institute at Christiania, Norway, in a letter to me says: "That you *introduce* the cloudforms into practical meteorology is certainly very good." It is of little use to make maps of the clouds unless we understand something of their significance.

The reviewer states that I claim for myself in conjunction with ex-President Hill, of Harvard, "the credit of originating the present Signal Service storm-warnings," but that we "were anticipated by Redfield, Henry, and others." A claim of this kind is hardly worth advancing or discussing, but I wish to correct misunderstandings. All I do claim is that in 1851, before any one else, I believe, I advocated and labored for a corps of meteorological observers connected by telegraph with a central office, so that the central observer might see the whole storm continuously in all its extent from beginning to end.

I would earnestly urge a popular interest in meteorology, since no other science is so open to those occupied in other pursuits, and scarcely another of so much practical importance. We all know men of no scientific acquirements, yet who are so well versed in signs of the weather that their predictions are more to be relied on for a particular locality than the very general "Probabilities" of the Signal Service. Such weather-wisdom is founded upon accurate observations of nature, and the explanation of weather signs is often very simple. For instance, it is an old Indian observation that Summer storms follow the course of rivers. The explanation of which is that Summer storms are mostly produced by the advance of colder air, which being heavier, sinks into and follows the valleys, at the bottom of which there is usually a water-course. Again, a halo round

the moon indicates rain, since its cause is the partial obscuration of the moon by the first hazy clouds of an approaching Northeast storm. With a knowledge of the connection between the clouds and movements of the air, it will be comparatively easy for any one to predict for his own locality the weather he is to expect from day to day. That this is practicable, is proved by the experience of many, and by an able article on the subject in the Galaxy Magazine for November, by Mr. F. Whittaker.

In connection with the importance of clouds in practical meteorology is the following statement in the scientific record of Harper's Monthly for August, 1875, edited, I believe, by Prof. Spencer F. Baird, of Washington.

"Dr. Hildebrandsson, of Upsala, has published the results of a careful study of observations of cirrus clouds. Having secured by personal correspondence a number of careful observers throughout Europe, he has compared the observed movements of cirri with the prevailing clouds and isobars at the surface of the earth. He finds that the cirrus clouds, in a large majority of cases, flow *out* from areas of *low* barometer, and *in* toward areas of high pressure, and, as he succinctly expresses it, the movement of these clouds is toward a point some distance to the right of that toward which the lower clouds move. We had occasion, a few years ago, to announce precisely the same law, as deduced by Prof. Abbe for the United States. It would seem, therefore, a law applicable to the whole of the northern temperate zone, and is entirely in accordance with the mechanical theory developed by Mr. Ferrel in a memoir published in 1860."

The same fact is referred to in Harper's Weekly, January 15, 1876, as follows: "Clement Ley so well known by his investigations into the movements of storms, states, in reference to the movements of cirrus clouds, whose laws have been investigated by Hildebrandsson and others, that his own observations fully confirm those of the latter as to the motion of the upper clouds, with only this modification, that the vertical axis of a revolving storm, about which the whole mass of air may be supposed to rotate is not exactly vertical, but inclined backward."

The writer evidently considers this isolated fact a very important discovery, and it really is the first attempt on the part of the cyclonists to consider the motion of clouds as well as their forms, and I might almost say the first step towards bringing the clouds into connection with storms.

As the cyclonists see the storm in the "area of low barometer," and the opposite of the storm in the "area of high barometer" their "*anti*-cyclone," it is natural that they should describe the motion of cirrus clouds in relation to these phenomena. But as the origin and nature of these phenomena are as yet unknown to them, the cause of the motion of the cirrus clouds in the direction described remains also unknown, and forms thus another puzzle besides the many we have already in the science.

As to the precedency in the discovery of the fact in question, I would draw your attention to my article—"New Theory of Storms," in the New York Times, November 18, 1852, reprinted and more fully elaborated in my recently published work—"Storms, their Nature, Classification and

Laws." It will be seen from this article that I observed the fact as to the motion of cirrus clouds besides others of a like nature about a quarter of a century ago, lectured on it publicly and published it. Copies of the article were sent to Prof. Henry and Lieutenant Maury in Washington. This article which was a sketchy summary of my investigations, contains also the laws of the motions of the lower cloudforms, such as cumulus, cumulo-stratus, conus. And it contains not only the laws as to the direction the different cloudforms take, but also an explanation of the causes of their motion, and the application to the prediction of storms. I mention these facts to show the overpowering influence of recognized authority in accelerating or retarding the development of a Science. Truth of the greatest importance often remains unnoticed if it does not pass first from the lips of a well-known authority, and errors may be propagated for centuries under the shadow of a great name. Although late, it is gratifying, however, to see my observations confirmed as the heavy train of Science moves onward.

Another reason why my observations have remained unnoticed so long, may also be found in the circumstance that I have seen and described meteorological phenomena from a different standpoint from that generally taken. A circular ring will appear to one as a straight line, to another as an ellipse, and to a third one as that what it really is, according to the standpoint from which it is viewed. This is very apparent in looking at phenomena the whole of which we cannot see at once, such as the motions of heavenly bodies or storms; we then are likely to take things as they appear to be. So men thought for centuries that the sun moves and the earth stands still, and the cyclonists think even now that the wind in a storm moves around in a circle, or in an ellipse, or in a spiral, because it appears so. They see in the "area of low barometer" the whole storm, while I from my standpoint see in it only the effect of the storm. The cyclonists see in the areas of *low* and *high* barometer independent although unexplained phenomena; to me these phenomena appear to belong together as organic parts of the storm and assume thus a meaning. With me a progressive storm consists in the displacement of one of two opposing air currents by the other, which is of different temperature, and the area of low barometer forms itself during this conflict between them by the rising of the warmer current obliquely over the colder one. The rising air produces lower pressure, but the full weight of each current produces the areas of high barometer in front, and in the rear of the area of low barometer. I, therefore, see the storm extend over much larger area than the cyclonists do.

I see in the ærial currents the elements of the storm, the cyclonists seem to consider them as the consequence of the storm. I, therefore, naturally consider the motion of the different cloudforms in reference to the ærial currents, and not in reference to barometric pressure, but the facts of their motion are and remain the same.

The "cirro stratus" of Howard—in fact all cirrus clouds—move with the

warm equatorial current, because they are originated by it as it ascends into colder regions obliquely over the colder polar current. The "cirro-stratus" I described in the Times article in 1852 as the embodiment of a fully developed north-east storm, because I found it characteristic by my observations of an approaching equatorial, warm current. I, therefore, consider it an elementary form, and proposed the single name "stratus," used by Howard hitherto for ground fog, which I consider of no form. The name "stratus" admirably indicates the stretched-out, straight-line cloud; it represents with my two other elementary forms—cumulus, conus—geometrical forms and is therefore easily described. The other forms of cirrus, commonly known as mare's tails, cat's tails, etc., are mere modifications of the stratus (cirro-stratus of Howard) forming during the first irregular attempts of the rising warm current before it has assumed its regular lateral motion in which the cirrus forms assume that of the stratus at the top of the regular front waves. We therefore see "the cirrus clouds flow out from areas of low barometer" (the place of the obliquely rising warm current) "and *in* toward areas of high pressure" (the colder polar current). My article twenty-four years ago, therefore, tells not only the facts about the motion of cirrus cloud which Hildebrandsson, Ley and Abbe have recently observed, but also the cause. Besides this it contains the practical application to predict from the appearance of these clouds above the southern horizon the coming of the equatorial current, or the approach of a north-east storm. While thus from the standpoint of the cyclonists the cause of the empirical fact cannot be explained, it follows as a natural consequence when seen from the standpoint I have taken.

The article in question contains also the laws of the motion of lower cloudforms, such as the cumulus, cumulo-stratus, and conus, and why they take their respective course, and how the movement and condition of the currents of which they are characteristic, i. e., the storm may be predicted by their appearance. The study of cloudforms *in connection with ærial currents* is one of the most important duties of practical meteorology.

As to Clement Ley's proposition, "that the vertical axis of a supposed revolving column of air is not exactly vertical, but inclined backwards," I would call your attention to a third opinion held by some most eminent meteorologists, such as Dove, Reid and Redfield, that the axis is inclined forward. The cyclonists run here again into a fresh contradiction, and create a new puzzle, some saying the axis lies forward, some it lies backward, and others it is vertical. It reminds us of Redfield and Espy's discussions, where one maintained that the wind in a tornado moves around in a circle, the other that it blows in straight lines toward the centre. These discrepancies are a consequence of the mode of investigation universally followed in this science, which is to deduce results from a conglomerate mass of disconnected data, obtained indiscriminately from storms that may differ as widely in origin and character as a bat and a sparrow. What have we gained towards an individual knowledge of either the bat or the sparrow by eliminating from a number of data the mean velocity and the

average direction of their flight? We mix things that do not belong together and arrive at best at indefinite, vague and unreliable results. This evidently has happened in determining the direction of the axis of a supposed revolving column of air.

The discrepant views of the celebrated meteorologists above mentioned, will all harmonize if considered from the standpoint indicated in my recent work. The supposed revolving column of air is seen from my standpoint as the obliquely rising equatorial, or warm current; its direction always inclines towards the north, or colder region. It thus coincides with the position of the axis of the supposed revolving column; in a north-east storm it is inclined forward, in a south-east storm backward, in a local storm it is vertical. The method of averaging will lead to the first result if the cases subjected to investigation belong all or in the majority to north-east storms; it will lead to the second result if the cases subjected to investigation belong in the majority to south-east storms; it will bring no result, or make the axis vertical if the cases or data subjected contain a number of both kinds in equal proportions.

Mr. Blodget remarked that there were very striking and valuable suggestions in Mr. Blasius' paper.

He thought that it was true that the influence of the Signal Service was in danger of being weakened by its persistent observations of only three hours in the day. Storms require observation continuously during their course. He agreed with Mr. Blasius, also, in accounting of inferior values other elements of the discussion of storms, those areas of low and high barometer which almost exclusively occupy the S.S. maps. He described the remarkable storms of 1873, accompanied with disastrous floods. They were not parts of a common storm usual to the Temperate Zone, raining from the lower portions of the atmosphere coming from the Gulf; but on the contrary, they were numerous local furious downpours from a hot supersaturated upper air coming from some more distant, unknown region in the South. They had the characteristics of tropical storms, and were so local, that in some instances a distance of only twenty miles sufficed to distinguish a flooded locality from one on which no rain fell. Mr. Blodget added, that, having in former years participated in the discussion of Espy, Redfield and Hare, he could meet the vertical theory with an expressed conviction of the impossibility, quite demonstrable, that a large storm should rotate upon the rough surface of the earth; although it must of course remain true that any disturbance in fluids has a tendency to set up vertical movements. The vast obstructive friction of the face of a country in the case of great air movements must always prevent any rotation over wide areas. Local tornadoes may produce small whirlwinds, but a Redfield cyclone is a physical impossibility. He had found in Mr. Blasius' book more of a true explanation of the origin and progress of storms than elsewhere. While Mr. Blasius had proposed the Signal Service system in 1851, he had himself used the telegraph in the Summer of 1852 for two months; and his charts

of that date show that he proved thereby, and then, the practicability of precisely determining the form and limits of any storm. All that he asked of the Signal Service now was to make continuous observations, instead of three observations a day, and to put down upon their charts the other more important elements with that of barometric pressure.

Prof. Houston noticed the fact that, by the barometer at the High School, the mercury stood, on the 5th of February at 1.20 P. M., at the most extraordinary height of 30.94. He wished also to put on record his proposed improvement of the barometer, at the mechanical details of which he is now working, viz: to read with greater ease and precision, by means of a scale floated on the surface of the mercury, counterbalanced and connected with a ring around the tube.

Prof. Sadtler, by permission of the Geological Survey of Pennsylvania, gave the scientific results of his recent analyses of gas from several oil wells in Western Pennsylvania—gas which is used in the iron manufacture.

CONTRIBUTIONS FROM THE LABORATORY OF THE UNIVERSITY OF PENNSYLVANIA.

No. VI.

On the Composition of the Natural Gas from certain Wells in Western Pennsylvania.

By Samuel P. Sadtler.

(*Read before the American Philosophical Society, Feb.* 18, 1876.)

Having had occasion lately to analyse some of the gases issuing from wells in Western Pennsylvania, I have obtained some results which are given as a contribution to our knowledge of these important natural products. There have been almost no analyses whatever made of these gases. In 1866 a French geologist, M. Foncou visited a number of these gas-wells and collected specimens of the gases. These were afterwards analysed by M. Fonqué, and the results are published in *Compt. rendus LXVII. p.* 1045. The localities were Pioneer Run, Venango Co., Pa.; Fredonia, N. Y.; Roger's Gulch, Wirt Co., W. Va.; Burning Springs, on the Niagara river below the Cataract; and Petrolia, Enniskillen district, Canada West. These points are certainly widely enough removed to make the series comprehensive from a geological standpoint. The analyses do not appear to have been complete ones, as M. Fonqué determined the exact amounts of only a few of the constituents. In general, the gases were composed of

members of the marsh-gas series of hydrocarbons. Thus the gas from Pioneer Run he found to have essentially the composition of propyl hydride ($C_3 H_8$), with small quantities of carbonic acid and of nitrogen; the Fredonia gas appeared to be a mixture of marsh-gas (CH_4) and ethyl hydride ($C_2 H_6$), with a small quantity of carbonic acid and 1.55 per cent. of nitrogen; the Rogers' Gulch gas was CH_4 almost exclusively, with 15.86 per cent. of carbonic acid, and a small quantity of nitrogen; the Burning Springs gas almost pure CH_4 with a little CO_2; the Petrolia gas a mixture of marsh-gas (CH_4) and ethyl hydride ($C_2 H_6$), with a small amount of carbonic acid.

However, in some cases the composition as given above was only apparent, as in the case of the Pioneer Run gas, for on passing the gas through alcohol a part was absorbed, which was afterwards shown to be butyl hydride ($C_4 H_{10}$), while the part unabsorbed showed nearly the composition of marsh gas (CH_4). It was evident, therefore, that what appeared to be propyl hydride ($C_3 H_8$) was in reality a mixture of marsh-gas (CH_4) and butyl hydride ($C_4 H_{10}$).

In 1870, Prof. Henry Wurtz made an analysis of the gas from a well in West Bloomfield, N. Y. The results of this analysis are found in *Silliman's Journal* (2) *XLIX.*, *p.* 336. He found:

Marsh-gas	82.41
Carbonic acid	10.11
Nitrogen	4.31
Oxygen	0.23
Illuminating hydrocarbons	2.94
	100.00

The specific gravity of the gas was .693.

The methods of analysis were not the usual ones of gas-analysis, but some new absorption methods devised by himself in conjunction with Prof. B. Silliman. This, I believe, is the extent of the published information on the subject.

The gases which I collected and analyzed were:

First, the gas of the Burns Well in Butler County; secondly, that of the Harvey Well in the same county; thirdly, that from the Leechburg Well across the Kiskeminitis river from Leechburg, in Westmoreland County and fourthly, the gas bubbling from a spring at Cherry Tree in Indiana County. As the results of Fonqué just given had rendered the presence of higher members of the marsh-gas series than CH_4 probable, at two of these wells, I made, in addition, absorption tests with absolute alcohol and with bromine, hoping to prove qualitatively the presence or absence of these higher hydrocarbons as well as those of the ethylene series. For while marsh-gas itself is insoluble in absolute alcohol, ethyl hydride ($C_2 H_6$) is dissolved to the extent of 1½ volumes, propyl hydride ($C_3 H_8$) to the extent of 6 volumes, and butyl hydride ($C_4 H_{10}$) to the extent of 18 volumes in one volume of the alcohol. A pas-

sage of the natural gas for 15 or 20 minutes, therefore, should saturate the alcohol with such of these hydrocarbons as might be present. The bromine absorption test was made in order to ascertain whether any ethylene or butylene dibromide would be formed by the passage of gas.

The gases tested in this way were the gas from the Burns Well and gas from the Leechburg Well. The bottles containing the alcohol, having been tightly stoppered and sealed at the time, were afterwards examined in the Laboratory. The Burns Well gas was first examined. The alcohol through which the gas had been passed was transferred to a small flask, and enough additional alcohol was added to completely fill the flask. A cork perforated and carrying a delivery tube was then fitted to it so that the excess of alcohol filled this tube also.

The flask was now heated, and the gas given off was collected in a eudiometer tube over warm water. I obtained thus some 150 cubic centimeters of gas. The operation was pushed until only alcohol vapor was given off, which was absorbed by the water. To the gas in the eudiometer I then added rapidly an equal volume of chlorine, and allowed it to stand exposed to diffused sunlight. Oily drops formed at once, while the volume of the gas contracted until it occupied only about one-half of the first volume.

This showed the probable formation of ethyl chloride ($C_2 H_5 Cl$) which is gaseous at temperatures over 12°C, and of either propyl chloride ($C_3 H_7 Cl$) which is liquid at temperatures under 52° C, or of butyl chloride ($C_4 H_9 Cl$) which is liquid at temperatures under 77.6° C. On inverting and applying a flame to the gas in the eudiometer, it was found to be inflammable, burning with the greenish flame characteristic of ethyl chloride. The water upon which the oily drops had collected, was put in a small flask, and an attempt was made to separate them by distillation. This was however, unsatisfactory, as there could only have been small quantities of either propyl chloride or butyl chloride. The water in the endiometer tube reacted acid from the H Cl formed.

The result of these tests may therefore be summed up as showing the certain presence in the gas of ethyl hydride ($C_2 H_6$) and the probable presence of either $C_3 H_8$ or $C_4 H_{10}$.

The qualitative examination of the Leechburg gas was made in the same way. I obtained here only about 100 cubic centimeters of gas on heating the alcohol. On mixing with chlorine a contraction of about one-third took place. The inflammability of the residual gas and the formation of oily drops gave the same indications as with the other gas.

The other qualitative tests were with bromine. This had been tightly bottled and sealed up. The bromine from the test with the Burns gas was then placed in a porcelain dish and water added. Pure sodic hydrate was added to neutralize the excess of bromine. The sodium bromide formed dissolved at once in the water. There remained no trace of oily drops such as would be caused by the bromides of the olefine series of hydrocarbons. The sodium bromide was afterwards crystallized out perfectly pure. The test was therefore entirely negative in its results.

On examining the bromine used for absorption with the Leechburg gas, there was apparently a slight layer upon the surface of the bromine, which might have been ethylene bromide. On neutralizing the excess of bromine, however, no distinct evidence could be had of the presence of the bromide, so that the result was left uncertain.

The quantitative analyses were next made. In these the carbonic acid, carbonic oxide, illuminating hydrocarbons, and free oxygen were tested for and when present removed by suitable absorption re-agents, while the hydrogen, marsh-gas and ethyl hydride were determined by the eudiometer analysis. Any nitrogen present remains over and is estimated at the conclusion of the analysis.

Burns Well Gas (average of two analyses).

Carbonic Acid	.34
Carbonic oxide	trace
Illuminating hydrocarbons ($C^n H_{2n}$)	——
Hydrogen	6.10
Marsh-gas (CH_4)	75.44
Ethyl-hydride ($C_2 H_6$)	18.12
Propyl-hydride ($C_3 H_8$)	trace
Oxygen	——
Nitrogen	——
	100.00

Leechburg Gas (average of two analyses).

Carbonic acid	.35
Carbonic oxide	.26
Illuminating hydrocarbons ($C_n H_{2n}$)	.56
Hydrogen	4.79
Marsh-gas	89.65
Ethyl-hydride	4.39
Propyl-hydride	trace
Oxygen	——
Nitrogen	——
	100.00

Harvey Well Gas.

Carbonic acid	.66
Carbonic oxide	trace
Illuminating hydrocarbons	——
Hydrogen	13.50
Marsh-gas	80.11
Ethyl-hydride	5.72
Propyl-hydride	trace
Oxygen	——
Nitrogen	——
	99.99

Cherry Tree Gas (average of two analyses).

Carbonic acid	2.28
Carbonic oxide	——
Illuminating hydrocarbons	——
Hydrogen	22.50
Marsh-gas	60.27
Ethyl-hydride	6.80
Oxygen	.83
Nitrogen	7.32
	100.00

It will be seen that the first three of the gases just analyzed are very similar in composition, while the gas escaping from the spring at Cherry Tree differs very considerably from the others. The larger amount of carbonic acid and the presence of free oxygen and nitrogen are the chief points which distinguish it. It is only natural, however, that a gas escaping from fresh spring water should contain these gases, as they are the gases usually dissolved in spring water. As to the other constituents of these gases, hydrogen, marsh-gas, and ethyl hydride are the most important ones. In the case of two of the gases, the Burns gas and the Leechburg gas, qualitative tests directly proved the presence of this last constituent. The other two ingredients can also be proved to be there by the application of Bunsen's formulas to the result of the eudiometric analysis. Thus, as the volume of gas taken for the eudiometric analysis can contain only hydrogen, hydrocarbons of the marsh-gas series and nitrogen, we need for our formulas four known values; the volume taken, the contraction after passage of the spark, the carbonic acid produced by the combustion and the free nitrogen in the sample of gas taken.

In the three gases first analyzed this last constituent proved to be absent, so that we had only three values, and could form only three equations, containing three unknown quantities. These equations were:

$$x + y + z = V. \quad (1).$$
$$y + 2z = C. \quad (2).$$
$$3x + 2y + \frac{5}{2z} = A. \quad (3).$$

where V equals the volume taken, C the carbonic acid formed, and A the absorption or contraction, consequent upon the explosion, where also x was taken as hydrogen (H), y was taken as marsh-gas (CH_4), and z was taken as ethyl-hydride (C_2H_6). When in these equations were substituted the found values of C and A, I got plus values for x, y, and z. On the other hand, if I assumed two constituents only, x as hydrogen and y as marsh-gas, the y was made equal to C at once, which was obviously incorrect, and would have given a minus value to x. If again, I assumed x to be equal to CH_4, and y equal to C_2H_6, I got false values for x and y. One other assumption only was open to me, that was to take x as hydrogen, y as marsh-gas (CH_4), and z as propyl hydride (C_3H_8). This would have given

plus values for x, y, and z, but the previous qualitative tests had shown conclusively the presence of $C_2 H_6$.

I found, however, unexpectedly in Fonqué's memoir the strongest confirmation of my interpretation of my results. Using the three equations that I have given above, he finds that when x, y, and z represent three successive members of the marsh-gas series, the equations are as follows:

$$x + y + z = V. \quad (1).$$
$$x + 2y + 3z = C. \quad (2).$$
$$2x + \frac{5}{2y} + 3z = A. \quad (3).$$

from which can be deduced as a fourth equation.

$$2A - 3V = C. \quad (4).$$

In other words, when an eudiometric analysis of a mixture of hydrocarbons of the marsh-gas series is made, the carbonic acid formed is equal to twice the contraction, minus three times the volume of gas taken.

He says, therefore, (*Compt. rendus.* LXVII. p. 1048) when the marsh-gas hydrocarbons are mixed with free hydrogen, this fourth equation is not realized. I did not find it realized in any of my analyses. Thus in the analyses of the Burns Well gas, I had the following figures:

	I.	II.
Gas taken	32.74	24.49
Contraction	70.4	52.75
CO_2 absorbed	36.6	27.5

If we substituted the values of C and V as found, in the formula $2A = C + 3V$, we get, for the first, $36.6 + 98.22 = 134.82$, of which the half is 67.41. But the observed contraction is 70.4, or 2.99 greater than that demanded by Fongué's formula for the marsh-gas hydrocarbons. So for the second we get $27.5 + 73.47 = 100.97$, of which the half is 50.485, while the observed contraction is 52.75.

If now we turn to to the formulas first stated by me, we find the explanation in the third equation where we have $3x$, assuming x to be hydrogen; and in the second equation where we have $0x$, assuming x to be hydrogen.

I have not been able as yet to make any experimental determinations of the specific gravity of these gases, but have the material reserved, and expect to do so. The specific gravities as calculated from the analyses given, are as follows:

	Sp. gr.
Burns Well gas	.6148

Mr. Lesley mentioned that Mr. Hall had found three casts of an *Orthis* of the Trenton (Bala) Limestone in a subangular fragment among the moraine (?) matter cut into for a drain in front of the University buildings in West Philadelphia.

Mr. McArthur presented through Mr. Walter nine photographs of models of ornaments for the Public Buildings.

Pending nomination No. 791 and new nomination No. 792 were read.

The minutes of the last meeting of the Board of Officers and Council were read.

Mr. Blodget, from the Committee on the Progress of Science Exhibition at the Centennial, reported that his Committee had met, and would act with a committee appointed by the Acad. Nat. Science, Phila. (Dr. Le Conte, Mr. O. E. Smith, Mr. W. Vaux), and he read a paper expressing the views of the joint committee, and explained that a room 24′ by 48′ in the southeast end of the Main Building, up-stairs, had been appropriated by the Commission to their use, and there was good reason to believe that learned Societies would respond cordially enough to fill this room.

Prof. Campbell disclaimed for the Commission all responsibility, except for guaranteeing the right of placing whatever it saw fit in this room by the joint committee.

Prof. Fraley said that an application would be made to the Society for permission to exhibit its Elliot Bible.

There being no other business, the meeting adjourned.

Stated Meeting, March 3, 1876.

Present, 10 members.

Mr. Eli K. Price in the Chair.

Letters of acknowledgment were received from Dr. Jacob Bigelow (95); Silliman's Journal (95); the Smithsonian Institution (95); the Emden Society (92); and the Physical Society in Berlin (87 to 91; xiv, 3, xi, 1).

Letters of envoy was received from the Coast Survey; from the Physical Society in Berlin; and from the

Royal Irish Society, requesting missing Parts 2 of Vol. iii, 1

of xiii, and 2 of xiv, to complete the set, which was on motion so ordered; also from

The K. Leop. Car. Deutsch Akademie der Naturforscher requesting exchanges, having only Trans. Vol. I. O. S. 1769. The request was referred to the Publication Committee with power to act; also from

A. J. Holman & Co., 930 Arch street, tendering a request for the loan of the Elliot Bible in the Library of the Society. The request was referred to the Library Committee with power to act.

The request of the Philadelphia College of Pharmacy for No. 93 to complete their set, was granted.

Donations for the Library were received from the Geological Institute at Vienna; the Leop. Car. German Academy at Dresden; the Prussian Academy, and Horticultural Society, and Herr Schwalbe of Berlin; the Society at Emden; the Belgian Academy; the Geographical Society and Reviews in Paris; the R. Astronomical and Geographical Societies in London; the Natural History Society at New Castle; the R. Irish Academy; the Boston Society N. H; the Cambridge Museum C. Z.; Silliman's Journal; American Chemist; Dr. J. S. Newberry; Poughkeepsie Society of Natural Sciences (ordered to be placed on the list to receive the Proceedings); Journal of Pharmacy; Penn Monthly; U. S. Department of the Interior; U. S. Coast Survey; Georgia Historical Society, and the San Francisco Mercantile Library Association.

Mr. Wootten communicated, through Dr. Cresson, a paper on the successful use of anthracite coal-dirt on a new form of locomotive, drawing coal trains, on the Reading Railway, and described on the blackboard the form of fire-box floor, draft tuyeres, absence of exhaust and smoke stack, length of flame, &c., &c.

Pending nominations Nos. 792, 793 were read, and the meeting was adjourned.

A Combination of Apparatus by which ordinary Anthracite Coal-waste, from the Dirt-banks at the Mines, can be successfully and profitably burned in the Furnaces of Stationary and Locomotive Boilers.

By John E. Wootten, Reading, Pa.

(*Read before the American Philosophical Society, March* 3, 1876.)

Prominent and peculiar features in the landscape of the Coal Mining Regions are the enormous heaps of black and apparently useless material collected near the outlet of each mine. The nature of this material can be best understood by a brief consideration of the source from which it comes.

The coal measures are made up of veins of coal of varying thicknesses and constitution. The coal of which they are composed, especially in the thicker veins, has mixed with it layers of slate, sometimes in mass, at other times finely laminated and disseminated throughout the seam.

As the coal is found in beds interstratified with rocky formation, it is subject to similar accidents as are the rocks themselves when disturbed by convulsions of nature; therefore when portions of a vein are crushed and rendered unfit for use as marketable fuel, it must, notwithstanding its unfitness, be removed from the mine to permit access to the more valuable coal.

Seams of considerable thickness are usually divided into separate beds of varying thickness, by deposits of slate, which impurity must be removed in the preparation of the coal for the market; and the same seam may furnish several qualities of coal.

The great heaps of material to which we have referred, are thus the results of the various operations of mining and preparation of the coal for market. They contain therefore, in addition to the earthy matter, slate and rock already mentioned, a large portion of the purest coal taken from the colliery, not only that which is crumbled into small fragments during the operation of mining, but also that, which having passed through the breaking rollers is crushed into particles of too small size to be merchantable, and is for that reason consigned to the dirt heap. The last named contribution to the heap constitutes from twelve to fifteen per cent. of all the good coal that is mined, and is the result of the wasteful method which is employed to reduce the large lumps to the uniform sizes required by the demands of the trade.

Some of these heaps are the accumulations of half a century, and have been exposed during their formation to the action of the weather and such atmospheric influences as have lessened their value for heating purposes by loss of carbon and saturation with moisture.

We have therefore, in dealing with these masses as fuel, to overcome the difficulties consequent upon their containing a very large amount of incombustible matter, all of the elements for the ready production of clinker and incapability for producing an active or vigorous fire in the ordinary furnace.

To consume this material with useful effect, it is necessary either to sub-

ject it to a process that shall form it into masses of moderate dimensions, so that when thrown into a furnace, interstices may be left to allow of access of air to the surface of the lumps, in the same manner as is the case with ordinary lump coal; or else special means must be provided to retain and consume it in the furnace; and peculiar appliances be made use of to insure the passage of air through the fire-bed and its proper contact with the fuel. In either case provision must be made as far as possible for the prevention of the formation of large masses of clinker and the disposal of the ash.

The first method referred to, that of forming the coal waste into lumps of proper dimensions, by the admixture of clay or bituminous matter, or other cohesive material, can only be profitably employed when the cost of the operation is less than that of mining and preparing coal at the colliery.

Heretofore the largest proportion of the coal mined was from above the water level, and the comparatively low rate at which such coal was mined prevented the successful application of any processes for agglomeration.

As the coal above the water level is being exhausted and deep mining has become necessary, the increased cost has directed attention to the utilization of the waste coal under consideration.

A large investment of capital in machinery may bring the cost of manipulation below that of mining; but it is not likely that the run of the waste coal heap can be utilized by any such process, as it contains so large a proportion of foreign and incombustible material.

It is obvious that if the coal in its minutely sub-divided state can be advantageously consumed by means of any process or device which shall be moderately simple in its construction and no more expensive of maintenance, than an ordinary boiler furnace, the problem of utilization of coal waste will have been solved, and a very considerable economy in cost of fuel attained.

With this object in view, a method of consuming the material in question has been devised and may be described as follows:

Air is injected into a closed ash-pan by means of a steam jet passing through one or more tubes. These tubes should be cylindrical, when volume of air without much intensity is sufficient; but when greater intensity is desired, as in the furnace of a locomotive, they should each be formed of two frustrums of cones, united at their smaller diameters; the proportions of the larger and smaller diameters varying with the degree of intensity of blast required.

The mingled air and vapor pass through a perforated fire-bed into the fuel in the furnace, and are thus evenly distributed through the fire, the fuel being spread over the fire-bed to a depth of about three inches.

The fuel upon the grate is gently lifted by the blast from over the perforations, the finer particles floating upon the current until the carbon is consumed; a large proportion of the ash passing off in a finely divided state, with the draft out of the stack.

The decomposition of the vapor in passing through the fire, results in

the production of hydrogen and hydrocarbon gases, in addition to the carbonic oxide usually formed.

The blue flame of carbonic oxide is to a great extent replaced by that of the hydrocarbons and hydrogen. The combustion of this fuel resembling that of bituminous rather than anthracite coal; the flame extending occasionally to a distance of over twenty feet, instead of as many inches, as is the case in the combustion of carbonic oxide gas from ordinary anthracite coal burned in the usual manner.

The decomposition of the vapor causes a considerable reduction of temperature in the furnace. This cooling effect in the furnace does not, however, result in a loss of heat, as the re-combustion of the hydrogen derived from the decomposition of the vapor yields as much heat as was absorbed in its formation.

To insure the rapid and complete combustion of the fuel, and prevent the formation of solid masses of clinker, it should be repeatedly stirred upon the fire bed with a rabble-shaped tool. This stirring process is an important element in the successful use of the fuel under consideration, as it serves to relieve the fire from the finely divided ash, which is thus exposed to and carried by the draught over the bridge-wall or through the flues of the boiler into the stack.

The perforated fire-bed forms an essential feature of the device, inasmuch as the loss of fuel through the grate during the stirring process is thereby greatly diminished, the average loss being less than two per cent. of the coal put into the furnace, whilst the weight of the fuel used for steam generation and stationary and locomotive boilers, is but slightly in excess of that which would be required of standard marketable sizes of prepared coal when burned in the same furnace with the ordinary bar grate in the usual manner.

The perforations in the plate of the fire-bed, are made from three-eighths to three-fourths of an inch in diameter, and from two to three inches from centre to centre.

Wrought iron is preferred for making the perforated fire-beds, as that material admits of the use of a much thinner plate than cast iron, and consequently there is less liability to obstruction of the air passages.

The exhaust blast of the locomotive is altogether unsuited to the consumption of the fuel under consideration, as by reason of its impulsive and vigorous lifting action, it is impossible to maintain the fire in the comparatively quiescent condition requisite for favorable results with anthracite coal dirt.

The usual method of urging the fire by means of the exhaust steam has therefore been entirely dispensed with, and instead of discharging the exhaust steam directly into the atmosphere, its heat is absorbed as far as possible, by passing it through tubular feed water heaters before allowing it to escape.

By this means, feed water is introduced to the boiler at a temperature in excess of 212° F.

A locomotive engine, using coal dirt exclusively for fuel, has recently been engaged in hauling coal trains over the Philadelphia and Reading Railroad, generating steam freely without the use of any portion of the exhaust steam as a draught-promoting agent, the substitute being a continuous supply of air and vapor, introduced into a closed ash-pan as above described, aided by very small jets of live steam in the chimney for the purpose of facilitating the passage upwards of the products of combustion.

These results obtained from many boilers now using the apparatus described, show that the hitherto neglected and apparently valueless material, known as coal dirt, can be profitably used for generating steam, and that hereafter it must be regarded as a fuel of great value.

Stated Meeting, March 17, 1876.

Present 16 members.

Dr. Bridges in the Chair.

A letter acknowledging the receipt of Trans. V. and Proc. 94, was received from the Boston Society of Natural History.

Donations for the Library were received from the Bureau of Mines at Victoria, the Society of Physical Science at Bordeaux, the Revue Politique, Canadian Naturalist, Boston S. N. H., American Antiquarian Society, Bedford Library, Astor Library, Franklin Institute, Medical News, Prison Discipline Association, Geological Survey of Pennsylvania, Geological Survey of Ohio, and President Allen.

Prof. Houston communicated again his views respecting the so-called new force, and in reference to certain strictures which have appeared in print, since his former communication. He described the results of experiments proving a polar condition of the force, and demonstrating the impossibility of its being anything but electricity under stratical tension.

Mr. Eli K. Price continued the communication of his views on the Glacial Epoch, so-called, arguing against a general polar outspread of ice, and for the explanation of all drift phenomena on the theory of iceberg distribution.

Prof. Chase exhibited diagrams representing certain mathematical and astronomical relationships of length, orbital movement and planetary distance, which he stated and described, including in his subject matter of discussion the possible influence of the meteor-belts.

Pending nominations Nos. 792, 793, and new nominations Nos. 794 to 802 were read.

On motion, the Committee appointed at a previous meeting to consider the expediency of an exhibition of the Progress of Science in the last hundred years, was discharged from further consideration of the subject.

A request by letter from Mr. Etting that the Society permit the exhibition of its original draft of the Declaration of Independence by the city in the Museum of the City Hall, was, on motion, referred to the Curators to report.

And the meeting was adjourned.

ON SOME DISPUTED POINTS IN PHYSIOLOGICAL OPTICS.

By Henry Hartshorne.

(*Read before the American Philosophical Society, April* 21, 1876.)

I. On the Theory of Erect Vision, with Inverted Retinal Images.

As it has been ascertained, by both mathematical and physical demonstration, that the image of every object seen must be inverted upon each retina, several explanations have been offered for the correspondence of our sight with the actual position of visible things. The most prominent views advanced are the following:—1. That we do see everything inverted, but that the correction has been obtained, and has become habitual and momentary, through *experience;* 2, that the reversal of all images is effected by the crossing of the filaments of the *optic nerves;* so that, e. g., all the filaments from the upper part of the retina go to the lower part of the optic ganglia at the base of the brain, and *vice-versa;* 3, that we do not mentally regard the image or picture *upon the retina* at all, but look *from* the retina, *at the object;* or, as one authority upon the subject prefers to express it, "the local change excited in the retina must be conveyed to the optic nerve, communicated to the brain, and again, in an inverted direction, projected outward; through this double inversion the projected image corresponds to

the object, and we therefore say we see the object when only the projected retinal image is before our eyes."

Against the hypothesis of the correction of inverse vision by *experience*, we have, first, the clear and, so to speak, imperative testimony of every one's consciousness; secondly, the very satisfactory observations and experiments of Spalding and others, upon newly hatched chickens and new-born pigs. The chicken just out of its shell, or one, after hatching, hooded for a day or two and then allowed to see, will *at once* locate an object brought near it (as an edible seed or grain), seizing it accurately with its bill; and will, also, *at once* run in answer to the cluck of the hen, almost always in a *direct line*. Similar facts, precisely, have been observed with pigs immediately after their birth. Thus, *in these animals*, the non-necessity of experience, even for the visual measurement of distances at short range, is proved; much more then must it be impossible that experience should be needed to set things upright, they being inverted according to actual vision. While analogy here only affords a probability as to what is true with regard to human sight, that probability is nevertheless very strong indeed: not that correct visual impressions in all respects are *congenital* with man, as our observation of infants does not seem to show; but that at least the simpler elements of vision attend in their development the maturity of the eye as an organ; and that among these elements, the sight of objects as not inverted must be one of the simplest. If it be said that the readiness for use of the senses and faculties of some new-born animals is a result of hereditary transmission, *a race-experience*, accumulated through long periods of time, I have nothing to say against this as, in itself, a not improbable hypothesis, in regard to the mode of *origin* of such endowments. But the idea of experience which is involved in the view just above-mentioned, is quite different from this last. Experimentally acquired corrections of positive sensory perceptions never go so far as to *annul* the perception which has to be corrected, to such an extent that the *process* of correction *cannot be ascertained by consciousness*.

On the hypothesis that the inversion of the retinal images is effected by a uniform decussation of the optic nerve-filaments, it is needful to remark only three things: 1, that this must be a pure assumption, no such mode or plan of arrangement of the filaments of the optic nerves being anatomically discoverable; indeed, a much more general and intricate plan of exchange of filaments, between eye and eye, optic ganglion and its fellow, and all the parts of the two eyes and the two ganglia, having been proved to exist; 2, that such an explanation is opposed to all the analogies of nerve-distribution, in regard to the localization of impressions; the relative *position* of the nerve-*trunk* or its filaments, never affecting much if at all, our perception of the locality of any sensation; all notions of locality or direction, under normal circumstances, being obtained by means of, and *at* the *organ*, not the transmitting or communicating nerve, of sense which is concerned; 3, that the same reversal of position of the image or picture on the retina produced by rays from an object seen, must occur *horizontally* as well

as vertically, the rays from the right side of the object crossing those from the left side as they enter the eye, so that (as in a mirror) what is right side in the object is left side in the retinal picture, and conversely; the difficulty of the anatomical explanation referred to being at least doubled by this *complication* of reversal.

It remains here for me to assert my adherence to the opinion, which is generally growing in favor with physiologists, that much the nearest approach to a solution of the problem of upright vision with inverted retinal images must be expressed in terms essentially conforming to the 3d of the hypotheses above briefly stated. The phraseology used in the passage which I before quoted, making "an image projected outward" that which (not the object) is seen, does not appear to me to be necessary, although it has convenience in describing the analysis of some of the phenomena of vision.

That which it is especially my design to remark upon in this connection is, the clear illustration furnished by our visual experience, and sustained by that of our other senses, of the *externality* belonging to, and inherent in, all sense-perceptions. *Direction* of sound is apprehended, even with only one ear open to receive it; the precise *rationale* of our recognition of the direction of sounds not yet being agreed upon amongst physiologists. I believe that it is obtained by the exquisite sensibility of the orifice, and parts near it, of the external meatus of the ear; a sensibility intermediate between auditory and tactile sense; a kind of gradation existing here, which, there is reason to think, has many illustrations in the partially differentiated sense-organs of lower animals. So, also, we judge, in case of touch, of the *direction* from which anything comes, a ball, for instance, striking the hand, by reversing, as it were, the central axis of predominance of the impressions made; which is analogous to the ocular visual axes, whose correspondence gives us single object-perception in sight.

II. On Extuition as a New Term in Psychology.

My reason for dwelling at some length upon the above points of statement is, that I conceive it to be of consequence in psychology (which in regard to sense-perception, especially, is inseparable from physiology), that a more distinct apprehension should exist than has hitherto prevailed, as to the essential, original and inherent, *externality* of the report made to our consciousness by *all* our organs of sense, of the impressions made upon them. In the but partially inductive study of psychology of past times, to which the term "metaphysics" may be, without disrespect, applied, the idea of the Cartesian formula, "Cogito, ergo sum," has been accepted in too exclusive or monopolizing a manner. This was, and is, a deduction occurring in the self-consciousness of the mature philosopher. Could a child, a year old, give its mental experience, so as to define its way of arriving at the knowledge of the *ego*, of its own personal existence and identity, it would doubtless say, "*Percipio, ergo sum.*"

Not uncommonly, authors on psychology assert, in effect, and sometimes

in their very words, that sensation is in the first place always *intuitive;* the process of perception then following, by which a reference of the quasi-subjective impression of consciousness is made, to an external cause. Now I believe that we are justified in denying the correctness of such language; and refusing to admit that sensation is *per se* intuitive, in any proper sense of that word. *Subjective* it may be, just in so far as it is an affection of the subject whose organs of sense (and through them the consciousness) are impressed. But I would insist that the affection of consciousness in sense-perception, nay, in primary *sensation*, is distinctly *objective* in its nature; at least to the extent that the bodily organ affected (not the central *ego* of the metaphysician, nor the brain which receives the terminations of the nerves of sense) is always, to us, the *immediate seat* of sensory cognition; while, at least in the cases of sight and hearing, *externality* belongs, by the law of our constitution, to sense-perception, in its primary nature; not needing a secondary process to attach the inference of outwardness to it. We cannot explain this farther than to say that it is the fact or law of sense-cognition, according to our bodily and mental constitution; but this is true of any and every other view of the subject which may be taken, whether old or new; and the legitimate aim of psychological science must be, as with any other science, to find by observation, experiment and careful induction, *what are* the facts and laws of mind, in all its actual relations. I believe that it may promote definiteness of thought upon this subject, to introduce a new term into psychology; namely, *extuition*. While the word intuition is, as familiarly used, well adapted to denote the reflective process, by which *ideas of reason* are obtained, it appears to be altogether misapplied when the same word is made (as by some leading authors it is) to indicate also the mental affection or act occurring in *sensation*. The importance, in my judgment, of this addition to the language of philosophy, of so explicit a term as extuition, conveying a meaning for which there is now actually no existing word, and scarcely a simple English phrase, is the *raison d'être* of the present communication. Word-making has always against it a strong presumption of uselessness, if not of impropriety; but in this case, the presumption seems to me to be over-ruled by a real necessity of thought and of expression. By means of the thought which is intended to be thus expressed, a satisfactory antithesis, and (as it is *inductive*) a tenable refutation, of Berkleyan idealism may be obtained; through the aid (too often overlooked by psychologists) of some of the most clearly demonstrable facts of physiology. Our sensorial consciousness affirms the reality and externality of the objective world, no less *simply, directly* and *positively*, than our reflective consciousness affirms our subjective being.

III. On Ocular Color-Spectra and their Causation.

In order to introduce a few observations which, if not novel, have at all events been but seldom noticed, and to bring forward what I believe to be a new explanation of a remarkable group of optical phenomena, it is need-

ful to refer to some facts familiar to most of those who have given attention to physiological optics.

When the eyes have been directed for a short time to a *bright* object, as a piece of polished silver, and they are then turned towards a white wall or other light surface, a *dark* spot or figure, having the outline of the bright object first seen, is beheld upon the white or light surface. Or if, on the contrary, a *dark* body, as an inkstand, for instance, be looked upon steadily for awhile, on turning the eyes toward a light ground, a brilliant *white* corresponding figure is seen. These are called *negative spectra*. If, now, instead, we look fixedly at a *colored* object, and afterwards turn the eyes to a white ground, or, if the colored body be *upon a white surface* and, after a time, this body be *removed*, we we will see, in either case, a spectrum having the *color complementary* to that of the object beheld. These are, also, commonly called negative spectra; the expression *complementary color-spectra* will designate them more accurately, without regard to theory.

It has been noticed that, near sunset, the rays of the sun passing through an orange-colored cloud cast bluish shadows; and likewise, the shadows of of objects seen behind red curtains are apt to be green. If the light either of the sun or of a strong artificial light be made to pass through a pane of colored glass, so as to fall upon a white ground, and a slender object, as a rod, or the hand, intercepts the colored light, the shadow thrown has the *complementary* color to that of the transmitting pane. Red glass will thus throw green shadows, green glass red, orange glass blue, &c. If we look at the shadow, so thrown, through a tube, so that it alone is seen, it is perceived as a shadow without color. Also, if the same shadow falls upon a *black* surface, no shadow appears.

The above mentioned facts have all been repeatedly observed; and but one explanation, so far as I can ascertain, has, as yet, been proposed for them.* It is that suggested by Dr. Thomas Young, and accepted by Helmholtz. Young's theory of colors, being the application to vision of Johannes Müller's general theory of special sensation (as depending upon the character of the sensory *organ* more than on that of the external cause), asserted the existence of different susceptibilities to color rays in different portions of the retina; or among the different optic nerve-filaments. With our present knowledge of the minute structure and relative functions of these parts, such special susceptibilities, viz: to red, green and violet light, as Young designated the primary colors, or to red, yellow and blue, as they are more commonly named, may be referred to the posterior layer of the retina; the layer of *rods and cones* of Jacob and Max Schultze. Helmholtz adopts this theory of Young, as the only one giving any clue at all toward solving the

*Since this was written, I have read, in Lardner's treatise on Optics, a brief statement of Plateau's theory, of an "oscillatory movement" of the whole retina, when affected with light, in connection with what he designates as a resistance of the retina to the action of any color, and a tendency to resume its ordinary condition, with a more or less intense force. There seems to be extremely little evidence in favor of this theory; and it has apparently fallen out of view in later works.

problem of the vision of colors; which, as the great German physicist declares, had baffled not only the powerful mind of the poet-philosopher Gœthe, but many able students of physics and physiology besides.

There seems to be no good reason for hesitating to accept this theory, of the special responsiveness of certain retinal nerve-elements to particular luminous rays. Helmholtz supports it by at least one striking fact in the comparative histology of the eye; viz: that in a number of birds and reptiles, many of the rods of the retina contain, at their ends which are turned towards the light, minute drops of colored oil; in some red, in others yellow; while others of the rods in the same eyes are entirely colorless. Also, he refers to the analogy of the *organs of Corti* in the cochlea of the ear; which are supposed, with considerable reason, to vibrate in accordance with particular notes of sound; and, also, to some remarkable external filamentous appendages to the organ of hearing in certain marine crustaceans; which Hensen, of Kiel, has shown to be set in motion, some by one, and some by other kinds of sonorous vibration. These last facts recall the admirable and similar series of experiments of Prof. Mayer, upon the vibrations of the antennæ of mosquitoes. I believe that there is much importance in this general theory of undulatory consonance, and of special responsiveness, of the minute elements of the organs of sense. It is in the *manner* of the *application* of this theory by Helmholtz, and, with him, by all other late physiological writers known to me, to the explanation of *negative* and *complementary color spectra*, and *color shadows*, that it appears to me a deficiency exists, fatal to the reception of that current explanation; and suggesting, if not proving, an almost or quite contrary view of the same facts.

The application I here mean to object to, is this: that negative and complementary color spectra and color shadows are all explained by partial or local *fatigue* of the retina, under impressions of light, so that the part of the retina impressed, e. g., by a particular color, becomes, through fatigue, less sensitive to the same color, kind, or degree of light; and therefore an impression is, during the time of that fatigue, made upon our visual consciousness only by the opposite or complementary rays; these affecting those parts or elements of the retina which are fresh, not having been wearied by use. According to this, when we look for a time upon a red object, those rods and cones, or nerve-cells, or nerve-filaments (or, as Prof. Draper would have it, portions of the *choroid coat behind* the retina) which are affected by red rays, become exhausted; and so, when we turn toward a white ground, we are, for the time, red-blind; while the *green-seeing* capacity, so to speak, is fresh and vigorous. Thus we see, at that time, only green; or, the complementary color in any other like case. This *fatigue* theory is what I am constrained, notwithstanding the very eminent authorities by whom it has been hitherto supported, to call definitely in question. Let me here mention the observations which first led me to look for a different view of the whole subject of these kindred phenomena.

If a piece of thin white paper, such as is commonly used, on account of

its light weight, for foreign correspondence, be laid over a piece of brightly colored material (paper, silk, flannel, or any other) and then on the latter a small black or dull colored strip or fragment of any kind be laid, under the paper, this *fragment or strip* will appear to be of the color *complementary* to that of the *larger and brighter ground* upon which it is placed. Any color will answer for this experiment; although the effects are most distinct with red and green grounds; tolerably so with bright yellow; least so with blue, purple, and all dark shades. It makes no difference what is the *hue* of the *fragment* or *strip* upon the brighter ground under the paper, so long as it is duller or darker, as well as considerably smaller, than the ground on which it is laid; it will always have the color complementary to that ground. Put, for example, together, under the thin paper, on a bright green ground, strips of blue, red and yellow glass, and one also of black worsted or paper; all of these, seen through the paper, will be, *alike*, distinctly *red*.

Now, on observing these facts, let it be noticed, especially, that the effect produced, the complementary color given, is *instantaneous*. The moment you look at the bright ground with the dull or indifferent strip over it, you *at once* see that strip with the *complementary* color. Lift the paper, and the real hue, or blackness, is seen; replace it, and it becomes again changed as before. There is here *no time for fatigue* of the retina, or of any part of it. Again, if the bright ground have, around it, a *margin* of the paper which is laid over it, that margin will have a faint but distinct *flush* of the complementary color. If the bright ground be *moved* to and fro, this overflush of color may be, sometimes beautifully, shown, following the line or edge of the moving mass of strong color; and most distinct near the edge. This effect, also, is instantaneous; there is no opportunity for *fatigue* in any way to explain it.

Finding then, this "fatigue" theory quite insufficient for these facts, attention to the phenomena of *color-shadows* above referred to, has impressed me with a belief that the same theory falls short with them also. They are, likewise, immediate, momentary effects. You look at the white ground, bathed in colored light, which light is partly intercepted by a narrow opaque object; and *at once* you see the shadow of the latter, having the complementary color; there is no possible time for fatigue, or for loss of any portion of the retinal sensibility.

Consideration may next be in place, upon a remark of Helmholtz,* which, though only parenthetically made by him, has very considerable importance. Bright objects, as flames, or the sun, when looked at, give subsequent spectral effects unlike those described as negative. They are, indeed, for a time at least, *positive* spectra. Helmholtz speaks, moreover, of from *half a minute to five minutes'* contemplation of a bright or colored object to produce the *ordinary* negative or complementary color spectrum by looking upon a white ground. I have found from *five to ten seconds* ample, with a kerosene students' lamp; and less time still, with strong sunlight.

*Popular Lectures, transl., 1873.

COMPLEMENTARY
INTERFERENCE
TINT.

COMPLEMENTARY

INTERFERENCE

TINT.

My experiments with sun-spectra, designed for the purpose of examining more particularly the above facts parenthetically mentioned by Helmholtz, were as follows: At about three o'clock on the afternoon of a clear day I held between my eyes and the sun, a pane of colored glass; using, at intervals, successively, four colors; blue, green, red and orange. After a few seconds, I turned my eyes from the glass upon a white-washed wall. In each case, a strong complementary (so-called negative) color spectrum was seen upon the wall; but, on *closing* my eyes, an almost equally intense *positive* spectrum, having, that is, the *same* color as the stained glass just looked through, appeared. Opening my eyes, the *complementary* spectrum returned; again closing them, the *positive* one; and so on, for half a dozen or a dozen times in succession. A member of my family, and, on another occasion, Prof. E. J. Houston, repeated this observation, with the same results; and I also did so, with entire success, with a magnesium light, at night. These experiments seem to me quite fatal to the supposition that retinal fatigue can account for any class of spectra such as have been above considered; for, if ordinary luminous impressions produce temporary fatigue and loss of sensibility, *stronger* impressions ought to produce still *greater* fatigue and greater loss of sensibility, or partial color-blindness, from that cause; whereas the reverse is the fact. As Helmholtz states, and as Newton found in his famous experiment, which proved dangerous to his sight, very bright objects, such as the sun itself, give *positive* spectra. In Newton's case, after gazing directly at the sun, its image did not pass away from his vision, whichever way he looked, for two or three days. Looking through colored glass, my daughter obtained a solar spectrum which continued for nearly twenty-four hours. In my experiments just mentioned, if it were possible for fatigue to account for the *negative* or complementary spectrum seen with open eyes, what conceivable relation (I certainly think none) can such a cause have, to the *positive* spectrum seen when the eyes were *closed?* If fatigue might *take away*, so to speak, the capacity to see green light when the eyes were *open*, it is against every "law of parsimony" in science to suppose that the same cause could *confer* the capacity to see a green image or spectrum, when the eyes were *shut*.

Another experiment, decisive against the fatigue theory, is one by which a *derived* or *secondary* spectrum may be obtained, as follows: a small square or circle of white paper or muslin is placed in the middle of a large brightly colored ground, red, for instance; and is steadily looked at for from a quarter to half a minute. The white central spot will acquire a tint of the complementary color (green, upon red), increasing in depth with prolonged attention, and especially strong at the nearest point of distinct vision. Then let the eyes be turned to a white ground; there will appear upon it the usual complementary (in the case supposed, green) spectrum, of the ground; but, at the *centre*, there will be also a clear *positive* (red) spectrum, corresponding in place and size, with the *white* central patch. Here, of course, that part of the retina which had received *only white* light, could not, on the fatigue hypothesis, be supposed to lose its sensibility to green,

through exhaustion from special use; while, on the theory which I am about to set forth, the mode of causation of the secondary as well as of the primary spectrum appears quite clear.

It remains, then, to attempt a definite answer to the question, what explanation, conforming with all these facts, can be substituted for that which I have ventured to pronounce unsatisfactory. I make an endeavor in this direction with diffidence; not possessing so precise an acquaintance with physics as might enable me to deal as an expert with so difficult a subject.

Allusion has been made above to four kinds of phenomena; which may be thus briefly named, *en résumé:*

a. Those of ordinary *color spectra*, primary and secondary, seen with moderate light.

b. Color shadows thrown under transmitted light.

c. Over-tints and *complementary shades*, seen through thin paper, on a brightly colored ground.

d. Solar color spectra, positive and complementary by turns, according to whether the eyes are closed, or opened towards a white ground.

These all appear to me to have a common character, and to require an essentially identical explanation.

Take, first, the ordinary color spectra, such as may be obtained with good lamplight. Looking at a red object for a few moments, one then turns the eyes to a white surface; a green spectrum is seen. Why is this? Because, to use the simplest and least hypothetical phraseology, the eyes are *charged*, *saturated* with red light; and this, having a certain strength, is *neutralized* by the red rays in light reflected from the *white* surface, so that only the *remaining*, complementary, green rays of that light affect the sight. Translating these expressions into language in accordance with the undulatory theory, I would say that, when a brightly colored object is looked at, those rods and cones, or minute retinal nerve-elements, which respond in vibration to the luminous ether-waves of the color reflected to the eyes, are excited to motion thereby; and by "irradiation," or communication of vibrations, all retinal elements which have *the same period of vibration* are made to partake, in some degree, of this movement. Then when, turning from the colored object, *white* light, consisting of all the color-rays or waves together, impinges upon the eyes, those ether-waves of the white light which belong to the color first acting on the retinal nerve-elements, *interfere with*, and for the time relatively diminish or *annul* the special vibrations already produced in the retina; leaving the *other* waves of white light to take effect upon the retinal elements which respond to or "resonate" with them, so that the *complementary* color only is seen.

Very probably *relative diminution*, rather than total arrest, of the special retinal vibrations, is what occurs. All our perceptions of light and color are, to a considerable extent, dependent on the *relative intensity* of light from different sources or of different kinds. When, then, in a beam of white light, a *portion* of certain color rays is, in effect, arrested by previously existing retinal vibrations of the same period, although the *remaining* rays

of the same color might affect the sight *if they were alone*, they are, as it were, overpowered by the unimpeded complementary color-rays. This consideration appears to me to meet an objection to my "interference" theory, suggested by Prof. Houston; derived from the necessary relation of *wave-length* of rays for interference. If only a moiety of the ether-waves of a certain color in a beam of light afford the required opposition of phase in undulation, their arrest or subtraction may yet explain the *relative* lessening of the intensity of that color, so as to cause it to cease to be perceived; the complementary color-rays having twice as great a strength.

When color shadows are produced by intercepting transmitted colored light, the shadows must fall *on a white ground*, or they do not have the color complementary to that which is transmitted. Here, again, the eyes becoming saturated with a certain color, *its* specially responsive nerve-elements in each retina are set in vibration; and, as in the other case, interference occurs between these vibrations and the ether-undulations corresponding with the same color, in the reflected (diffused) white light Let the shadow of the intercepting object fall upon a *black* surface, and the complementary color disappears. Nor will it be seen when only *monochromatic* light is present in the apartment.

Again, the above-described *over-tints* or flushes, and complementary interrupting spots, strips or bands, upon a colored ground seen through thin white paper, depend upon the *white light reflected* by that paper, for their complementary color. If the paper be removed, the actual difference between the ground and the spots, strips or bands laid upon it, will be clearly seen. Replace it, and *at once* a strong contrast re-appears; as before, I hold, resulting from the interference of equivalent vibrations.

Lastly, when a very strong impression is made upon the eyes, as by looking at the sun through a colored glass, the excitement of the nerve-elements is so great as to *persist* in the same manner; producing continued sensation of the same color, when the eyes are closed, for some time. But, when the eyes, in this state, are opened upon a white ground, again the waves of the *same* color-rays in the white light *kill*, as it were, that color in the eyes; or, in other words, arrest, for the time, enough of the existing retinal vibrations to annul their effect in sensation, so that only the remaining (complementary) rays of light are perceived. Bright reflected white light thrown even upon the *closed* eyes will have this effect.

An analogous explanation will suffice for the *secondary* or *derived* spectra, mentioned on a previous page. Looking steadily at a small white spot on a red ground, for example, the white spot becomes green; turning thence to a white ground, a large green spectrum is seen, with a red spot in the centre. The latter I call a secondary spectrum. While looking at the *red ground*, vibration of the *red-resonating* retinal nerve-elements began, and was extended, by irradiation, to those covering, in vision, the *white spot* in the centre; being, there, sufficient to *neutralize* the *red* rays of the white, and thus allowing only green to be seen, by vibrations of the *green-resonating* rods and cones of *that part* of the retina.

On turning then to a *white ground*, most of the retina being *charged with red* by the previously contemplated red ground, the usual *complementary, green*, spectrum of that ground is seen; but at the *central* part of the retina, whose *green-resonating* elements have been set in vibration (as above said), *their* vibrations are annulled by the *green rays* of the white ground; leaving only the red rays of that ground to take effect, and producing a (secondary) red spectral spot upon the green.

These facts are, it appears to me, all closely similar in nature to the commonly observed interference occurring between diffused sunlight and lamp or candle flame; and, also, they have a definite relation to the mode of production of the Fraunhofer dark lines or "absorption bands" of the spectroscope; while they suggest some further speculations in regard to what may be the molecular conditions of reflecting surfaces which give to our vision impressions of different colors, to enter upon which, at present, would extend this communication to too great a length. I may simply add that, on careful examination of ocular spectra obtained by looking at colored objects by lamplight, as well as by sunlight, I have become convinced that the influence of light entering through the *closed lids*, if they are uncovered and within range of a luminous source, such, even, as that of a student's lamp, is not at all indifferent. A spectrum, obtained as usual, seen with closed eyes, and fading away while they are covered, may be *renewed* by approximating the eyes, *still closed*, to the light; and this again and again, several times. In order to test yet farther the sensitiveness of the eye, when closed, to light, I placed several pairs of glass slips, of different colors (blue, red, green and orange), in the hands of an assistant; laying them, then, as given to me, in turn, upon my closed lids, while my eyes were turned towards the afternoon sun. In every case, I could discern clearly the color of the glass; but only in the direct rays of the sun; diffused daylight, and lamplight failed, with me, to give more than a doubtful discrimination of color, even with near contact of bright translucent objects, while the eyes were closed.

Incidentally, I may mention also, my careful repetition of a very curious experiment mentioned by Sir. David Brewster in his Optics, and brought to my notice by Prof. E. J. Houston. A strip of white paper is held vertically, about a foot from the eyes; the attention is then fixed upon an object at a greater distance, so that the slip of paper is seen double; and at the same time a lighted candle is brought near to the side of one eye, so that its light will affect that eye strongly. The image of the strip seen by that eye (if the *right eye* be illuminated, the *left-hand image*, and *vice versa*) will be *green*, and the other *pale red*. I find that, when these two images have been obtained, one eye can be closed, but the same color still remains. Brewster asserts that when *two* equal candle-lights are used, one being held near each eye, two *white* images will be obtained. With me, this does not prove to be the case. I see, with two candles, *two green* images instead; and, fixing the eyes on the strip for *single vision*, with two candles placed as before, it is seen of a *distinct green* color. Without insisting upon it, I would pro-

pose as a hypothetical explanation of these results, the throwing of *red light* upon the retina by the light of the candle passing *through the blood vessels* of the eye-ball; this red light, in the eye most illuminated, *killing* the red-light vibrations of the retinal elements, so that only green is seen. The pale red of the image seen by the *unilluminated* eye is, with me, of doubtful distinctness.

If the facts and arguments which I have set forth in this paper impress other minds as they have done my own, especially in view of the *instantaneousness* of many of the phenomena described, and on which I have wished to lay particular emphasis, it may, at least, be concluded, that the commonly accepted theory, proposing to account for negative and complementary spectra by partial *fatigue* and diminished *sensibility* in the retina, will not suffice; and ought to be abandoned, as not at all reconcilable with several clearly demonstrable facts. Should my above attempted explanation, by *interference* (or *saturation* of the retina with certain luminous rays, and *neutralization* of a portion of the same by equivalent rays present in reflected white light), not prove altogether satisfactory, it may be an interesting task, not without importance in physiological science, for some one well-versed in the physics of the subject to give it such farther attention as may solve the problem, in a manner which meets, as has certainly not hitherto been done, all of its conditions. I ask leave to verify some of my assertions as to the facts referred to in this paper, by repeating here a few of what appear to me the most decisive of the experiments which have been mentioned.

Stated Meeting, April 7, 1876.

Present, 19 members.

Dr. LeConte, in the Chair.

Letters of acknowledgment were received from the Batavian Society at Rotterdam (XV ii, 94); the Royal Observatory at Bruxelles (XV ii, 94); the Royal Astronomical Society (XIV); the Society of Antiquaries (95), and the Victoria Institute in London (95).

Letters of envoy were received from the Zoologico-Botanical Society at Vienna, March, 1876, and the Meteorological Office at London, dated March 20, 1876.

A letter requesting missing Nos. XIV, ii, 62, 88 was received from the R. Astronomical Society, dated February 16, 1876.

A letter was received from Mr. Cleveland Abbe, requesting missing Nos. 93, 94, dated Army Signal Office, Washington, D. C., March 20, 1876.

Donations for the Library were received from the St. Petersburg Botanical Society, Danish Academy, Königsburg Physical Society, the Societies at Ulm and Erlangen, Turin Observatory, Vaudois Society, Bordeaux Geographical Society, Paris Geographical Society, Revue Politique, Nouvelles Météorologiques and Journal des Orientalistes, London Astronomical Society, Meteorological Committee, and Nature, Greenwich Observatory, Boston Academy and Natural History Society, Silliman's Journal, American Chemist, Poughkeepsie Society, Buffalo Scientific Commercial, New Jersey Historical Society, Penn Monthly, Pharmaceutical Association, Medical News, and the Department of the Interior at Washington.

The Committee on Dr. Valentini's memoir reported that they desired further time to compare the photographs with the Mexican calendars in the Poinsett collection of the Society, which was granted.

The death of Theodore Cuyler, on the 5th inst., aged 55, at Philadelphia, was announced by Mr. J. S. Price, and on motion Mr. Henry M. Philips, was appointed to prepare an obituary notice of the deceased.

The death of Hakakian Bey of Cairo, a member of this Society, was reported by the Secretary.

A thesis entitled "Physiological Action of Strychnia, by Dr. Wm. H. Clapp," which had received a prize at the recent commencement of the Medical Department of the University of Pennsylvania, was offered for publication by Dr. Carson through the Secretaries.

A thesis entitled "Sanguinaria Canadensis and its Alkaloids" by Robert Meade Smith, A. B. which had received a prize at the same commencement, was offered for publication by Dr. Francis Gurney Smith through the Secretaries.

These communications were on motion referred to a Com-

mittee composed of Dr. Henry Hartshorne, Dr. Bridges, and Dr. Horn.

Mr. E. K. Price concluded the reading of his Discourse on the Glacial Theory.

Prof. Chase communicated, with blackboard illustrations, some astronomical ratios favoring the Nebular Hypothesis.

Dr. H. Hartshorne postponed the reading of his paper "On some disputed Points in Physiological Optics with experiments" to the next meeting.

Gen. Kane made a preliminary communication of his views of the Sub-carboniferous formation and of the structure of McKean County, Pennsylvania, based upon surveys pursued by him through many years.

Pending nominations Nos. 792 to 802 were read.

A report of the Curators was read recommending that the request of Mr. Etting be granted, and on motion, the Librarian was authorized to deliver to Mr. Etting the Original Draft of the Declaration of Independence, owned by this Society, and to take his receipt therefore, and his agreement to preserve the document in a fire-proof safe, except on hours of public exhibition, and protected from the direct rays of the sun, and to return the same on or before the first of January, 1877, according to the terms of his letter of March 23d, 1876.

A report of the Library Committee was read, recommending that the request of Holman & Co., be granted, and on motion the Librarian was authorized to deliver to Mr. Holman the Elliot Bible in the Library of this Society for exhibition in the Centennial Buildings, taking his receipt therefor, and his agreement to return the same in good order on or before the first of December, 1876.

The Treasurer's Report (postponed on account of illness) was read.

The resignation of Mr. Samuel J. Reeves as a member of the Society was read, and on motion accepted.

And the meeting was adjourned.

Stated Meeting, April 21, 1876.

Present, 17 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters of acknowledgment were received from the Institute National de France, dated March 31, (XIV iii, and asking for Vol. V i, N. S. and XIV ii), from the Radcliffe Observatory, Oxford, March 30, and from the New York State Library, April 15.

Donations for the Library were received from the Prussian Academy, Annales des Mines, Nouvelles Météorologiques, Revue Politique, Nature, Mus. Comp. Zool. Mass., American Chemist, Cap. Jas. C. Cole, Franklin Institute, Am. Jour. Med. Sciences, and Mr. A. H. Worthen, of Springfield, Illinois.

Dr. Ruschenberger was, on motion, substituted for Dr. Hartshorne on the Committee to report on the publication of the medical theses presented at the last meeting, at the request of the latter.

Dr. Hartshorne read a paper on complementary spectra, rejecting the commonly received "Fatigue Theory," and offering a new explanation based upon the interference of light rays, illustrating his views by means of colored papers, and the magnesian light.

Prof. Chase communicated certain relationships which he had worked out between the velocity of light and the rotation of Mr. Crooke's new rotation apparatus, and with the phenomena of the "Silenium Eye." To these he added some fresh calculations of the weights of the planets.

Prof. Frazer read a communication which he had received from Mr. Beyton Smith, C. E. of York, Pa., giving a sketch of the literature of the belief in one magnetic pole

of declination, and of the counter belief in the existence of two such northern poles; followed by a brief statement of the results of his own field observations and calculations, leading him to the conviction of the existence of two poles, and enabling him to locate their two ellipses of rotation, approximately; not as accurately as he desires to have it done by a more skillful mathematician; but with such an approach to exactness as to be practically useful in his own tests of the age of any given land line. Both poles are located nearly on the 70° parallel of north latitude; but while the ellipse of the American pole lies nearly in a North and South direction, that of the European pole lies nearly East and West. Mr. Smith is anxious to have mathematical assistance in projecting his ellipses upon a map or globe.

Prof. Houston desired the Society to make a note of some curious observations he had made recently while using Plucker tubes for obtaining the hydrogen spectrum, and modifying the internal diameter of their capillary tubes with a view to regulate the flow of the gas. In proportion as the resistance was increased, crimson spots and lines appeared, and finally the crimson color filled the entire space.

Pending nominations Nos. 792 to 802 were read, and balloted for, No. 793 being on motion postponed on account of the absence of the nominator.

The report of the Finance Committee was presented by Mr. Fraley, and the appropriations recommended by the Committee for the ensuing year, were on motion passed.

The ballot boxes being scrutinized by the presiding officer the following named gentlemen were declared to be duly elected members of the Society:

Col. Frank M. Etting, of Philadelphia.

Dr. Daniel C. Gilman, President of the Johns Hopkins University at Baltimore.

Mr. P. Cunliffe Owen, of South Kensington, London.

Mr. I. Lowthian Bell, of Newcastle on Tyne, England.

Mr. James Geikie, of Scotland.

Prof. Thos. C. Archer, of Edinburgh.

Dr. Adolph Erik Nordenskiold, of Stockholm.

Mr. C. Juhlin Dannfelt, of Stockholm.

Mr. Elihu Thompson, A. M., Prof. Chemistry in the Philadelphia High School.

Mr. Charles V. Riley, President of the Academy of Sciences, St. Louis, Missouri.

And the meeting was adjourned.

Stated Meeting, May 5, 1876.

Present, 10 members.

Secretary, Dr. LeConte, in the Chair.

Visitors: Mr. Deby, of the Belgian Commission, and Mr. König, of Paris.

Letters accepting membership were received from Mr. Frank M. Etting, of Philadelphia, and Dr. D. C. Gilman, of Baltimore.

A letter declining the appointment to prepare an obituary notice of Mr. Cuyler, was received from Mr. H. M. Phillips, dated 1325 Walnut Street, Philadelphia.

On motion, Mr. Phillips was excused.

Letters of acknowledgment were received from the Regents of the New York University, and Boston Natural History Society (V ; 94).

Letters of envoy were received from the Secretary of the Geol. Survey of Pennsylvania, May 4 ; London Meteorological Office, R. S. April 8, and Royal Astronomical Society.

Donations for the Library were received from the Academies at Buda-Pest, Vienna and Bruxelles ; the Societies at Bonn, Göttingen, Ulm, Zurich, Geneva, and Cherbourg ;

the National Museum, and Geographical Society at Paris; MM. Rütimeyer and Alb. Müller at Basil; the Meteorological Office and London Nature; the Boston S. N. H.; Mr. E. D. Cope; Prof. O. C. Marsh and Silliman's Journal; the Franklin Institute; Academy of Natural Sciences; College of Pharmacy; Penn Monthly; the Manager of the House of Refuge; Dr. D. C. Gilman, of Baltimore, and Mr. S. S. Sherman, of Milwaukee.

The Committee to consider the propriety of publishing the medical theses presented at a previous meeting asked and obtained leave to postpone their report for another fortnight.

Prof. Frazer read a *resumé* of the important points in the memoir and maps of M. Delesse, entitled Lithologie des Fonds de Mer.

Prof. Frazer, also, made some preliminary remarks upon the possible effects upon species and genera of living beings to be supposed to arise from variations in the proportionate percentages of the chemical elements of their physical constitution, under the operation of the law of the "survival of the fittest," leading to the conclusion that, were the chemistry of organic bodies suitably modified, it might be possible for them to exercise the functions of life in otherwise destructive circumstances, as, for example, in solar heat. He postponed the reading of a paper which he had prepared on the subject to a future meeting.

The reading of the pending nominations, &c. was postponed, and the meeting was adjourned.

Stated Meeting, May 19, 1876.

Present, 11 members.

Prof. P. E. Chase, in the Chair.

Mr. Selwyn and Mr. Carll, new members, were introduced to the presiding officer, and took their seats.

Visitors from corresponding societies, Mr. Honeyman and Mr. Lawson, of Nova Scotia.

A letter accepting membership (with photograph for the album) was received from Prof. Thos. C. Archer, dated Philadelphia, May 7, 1876.

Letters acknowledging the reception of publications were received from the Société Hollandaise, dated Harlem, February 1876 (XV ii, 94); the Foundation Teyler, dated Harlem (92, 93); the Statistical Society, London April 26, (95); the N. H. S of Northumberland, D. and N. upon Tyne, April 25, (95); the Royal Society of Edinburgh, February 21, (92, 93).

Letters of envoy were received from the S. Hollandaise March; Cent. Obs. St. Petersburg, March; Fondation Teyler, Harlem; and Department Interior, U. S., Washington, May 6, 1876.

Donations were received from the Royal Academy at Berlin; the Musée Teyler; Society of Anthropology and Revue Politique at Paris: M. LeComte Leopold Hugo, at Rome; the R. Geographical, R. Asiatic, and Chemical Societies and Victoria Institute at London; Nature; Radcliffe Observatory; M. Juhlen Deby: R. Society at Edinburgh; R. Dublin Society; Canadian Naturalist; Boston S. N. H.; State Board of Health, Mass.; American Chemist; Franklin Institute; Mr. John E. Wootten; Medical News; Second Geol. Survey of Pennsylvania; Department of the Interior and Engineer Department U. S., Washington; Dr. J. H. Kidder; Young Men's Association, Buffalo; and the Scientific Monthly at Toledo, Ohio.

The Committee to whom was referred the medical prize theses, reported.

Mr. Honeyman, by invitation, read a paper on the varieties of transported boulders found by him in the banks and "red heads" of the Nova Scotia shore for twenty miles east of Halifax, and along the harbor and railways to Winsor and Pictou; showing, by means of a colored map, and specimens containing fossils, and specimens of amygdaloid, agate, syenite, dolerite, diorite, granite, iron ore, &c., that the deposit at Halifax was the terminal and medial moraine of a glacier having its base along or behind the Cobequid mountains, 80 or 90 miles distant, and that the arc of collection and dispersion, of which Halifax was the centre of concentration, had an amplitude of 45°. The striæ on the rocks towards Halifax had an average trend of S. 5° E.; towards Windsor of S. 20°—30° E.; and towards Pictou of S. 25° W.

The thanks of the members present were warmly expressed by the presiding officer and others.

Professor Houston described some results which he had got with a Crooke radiometer in a good Geissler tube of his own manufacture, going to show that light was ancillary to heat in the action of the instrument. Presenting, however, non luminous rays of heat, as for example from heated copper, a small but decided motion was obtained. Moonlight gave no motion, but he intended to concentrate moonlight on the flags by means of a 16″ Fresnel lens.

Mr. Briggs reminded him that the thermopile revealed heat rays in the moonbeams, and an alum plate would be required to make the experiment satisfactory.

The minutes of the last meeting of the Board of Officers were read.

Pending nominations Nos. 793 and 803 were read.

On motion of Mr. Price, the Secretaries were instructed to reply to Mr. Kesselmeyer's letter, respecting the Calendarium, declining his proposals.

And the meeting was adjourned.

NOTE ON THE "LITHOLOGIE DU FOND DES MERS" OF M. DELESSE.

By Prof. Persifor Frazer, Jr.

(*Read before the American Philosophical Society, April 21st,* 1876.)

M. Delesse acknowledges his indebtedness to the treatises in Geology of Elie de Beaumont and Jas. D. Dana, in the first few prefatory pages. The following shows the scope and direction of the work:

I. Preliminaries. Methods pursued in studying the deposits. Orography of France and her submarine shores.

II. Principal agents of marine deposits.

Organic agents.

Inorganic agents { External { Atmosphere. / Fresh and brackish waters. / The Sea. } / Internal { Subterranean waters. / Eruptions. / Dislocations. }

III. Marine deposits of the Coast of France. Shore deposits and submarine deposits. Distribution of Mollusks.

IV. Lithology of the principal seas of the globe. France. The ancient world. The modern world.

V. France at different geological epochs. Deposits of the ancient seas of France. Changes undergone by these deposits.

M. Delesse then describes his methods of investigation.

Fine sand is treated with hydrochloric acid, its loss of CO_2 determined, and this multiplied by 2.27 to obtain the carbonate of lime. This method is accurate enough. Magnetic iron is separated by a magnet. Part of the gangue comes out with the magnet. This augments the magnetic sand on the one hand; on the other much of the magnetic sand is not taken up; so that these two errors are on opposite sides.

Sands and gravels examined contained 0.54 to 2.70 p. c. of soluble material (sea salts and organic matter). Argillaceous sand has a tendency to remove salts from the water containing them.

The classification of the deposit was had without recourse to chemical analysis, by the microscope.

The sieve used had meshes with a diagonal of 1 mm. The universality of the presence of quartz is very striking. Even vegetable mould and that too resting on calcareous rocks show a notable proportion of quartz. Quartz is more abundant the more the waters are agitated.

The sand dunes of the coasts of France are mainly composed of hyaline quartz, whitish gray. They slope gently towards the sea at about 7°; landwards about 29° to 35°, and have been seen to advance in a high wind in spite of a heavy fall of rain 0.6 m in three hours. The absence of mud in dunes is noteworthy but easily explained, since this substance hinders the formation of dunes.

The minimum rainfall in France is in the region bordered by Troyes, Meaux, Compiègne, Epernay (40 centimetres).

On the Ain (one of the affluents of the Upper Rhone) it is over 120 centimetres.

Up the Seine from Paris about 28 p. c. of all the water which falls in whatever form finds its way into that river (within that hydrographic basin); 53 p. c. in the basin of the Saône near Trevoux. For the Garonne above Marmande and for the Auxois which flows over impermeable marls it rises to 65 p. c. The percentage increases in schistose and granitic regions.

It is noticeable that the rivers which flow over calcareous beds do not exhibit a large amount of limestone in their *débris*, as for example the Loire. This is attributed to the softness of calcareous fragments and their inability to resist triturition. [It may be remarked that this explanation will only apply to the deposits at considerable distances from the edge of the calcareous formation, for otherwise the waste would be constantly renewed.]

400 metres from the mouth of the Lez the sandy deposits contain over 60 p. c. of carbonate of lime. At the mouth it consists of 23 p. c. carbonate of lime, with great numbers of flakes of green mica.

The Herault 600 m. from its mouth deposits a reddish gray gravelly sand, consisting of hyaline quartz with orthoclase, feldspars and granitic *débris*, much argillaceous schist, reddish brown mud, gray mica schist, greenish quartz, sand, and some tablets of silvery mica.

Magnetic sand is found here in large quantity and is derived from the igneous rocks over which the river flows.

These few notes will serve to convey an idea of how this part of the subject is treated.

By far the most striking, as the most valuable, part of M. Delesse's work is to be found in the elaborate charts which accompany it. The character of these charts as specimens of map printing is very high, although it is questionable if the condensation of a great number of unallied statistical facts upon one sheet is favorable to the easy comprehension of such charts. A better plan would be to reproduce the same outline several times with different and strongly marked coloration or shading than to construct all curves of every kind upon one frame work, thus causing them to cross and recross one another to the bewilderment of the eye. Another difficulty for the reader arises out of the method adopted by M. Delesse for conscientiously representing all his facts upon a single sheet. Had the several kinds of curves been strongly portrayed they would so attract and confuse the eye as to entirely destroy the effect of the map as a whole. To avoid this the lines have been made so exceedingly fine, that if any one try to follow one of these curves he will need either an exceptionally good eye or a magnifying glass; in either case the character of a *boundary* between a territory on one side and a territory on another fails; for the moment the observer seeks to take in the entire curve at a glance it becomes invisible.

The datum plane is sea level. Heights are registered in the metre curves and depths by similar means. But in approaching the mountainous regions of France, one half the contour lines are omitted, lest they should shade

these portions of the map too deeply to allow of the delineation of the other portions. The unnatural effect is produced, of a map constructed on two different hypsometrical scales.

The distribution of rock, sand, slime, etc. along those sea bottoms which have been best observed (as for instance in the British Channel and along the routes of various deep sea sounding lines) is very interesting.

The great distance to which fluviatile sediments are carried and the separate although adjoining areas which the suspended matters of two widely separated river systems will occupy is strikingly shown in the distinct belts of St. Lawrence and Mississippi sand which overlap for 500 miles along our coast without commingling.

For his contribution to our knowledge of our own coasts M. Delesse deserves the hearty thanks of every student of American physical geography and geology.

Mr. Lesley added his testimony to the great value of the work of M. Delesse, of which Prof. Frazer had spoken:

He hoped that the Lithologie du Fond des Mers would be translated into English, and the magnificent maps accompanying it republished for the use of American geologists. If only the one map of the American continent and its enclosing water-beds were published, showing by colors the different sediments which issue from our rivers, and are distributed by tidal currents along our coasts, it would be a most valuable addition to our handbooks of geology. Many of the problems of erosion and sedimentation in Mesozoic and Kainozoic times, are plainly helped to solution by this map.

One of the most striking features is the contrast between the sediment in front of the coast from Maine to Alabama, and that of the sediment filling the St. Lawrence Gulf, and tapering southwards to a point opposite Norfolk. The former sediment fills the in-shore angle of the Gulf of Mexico, in front of Pensacola; the latter is repeated as an outside belt, stretching from the mouth of the Mississippi to a point in front of Havana.

It is easy to see the cause of the difference. The inside sediment descends the rivers which drain the siliceous and feldspathic mountains of New England, New York and Pennsylvania, Virginia, the Carolinas and Georgia, composed of Azoic and Palæozoic formations. The outside sediment descends the St. Lawrence and the Mississippi, and represents the drainage of the argillaceous and calcareous interior of the continent, composed of the Sub-carboniferous limestone formations east of the Mississippi, and of the broad stretches of Cretaceous and Tertiary rocks between the Mississippi and the Rocky Mountains.

The map suggests plainly the cause of the difference between the constitutional features of the eastern and western Cretaceous and the eastern and western Tertiaries.

A thousand details of this nature will repay the student of the map, to construct which must have tasked the zeal, as well as the knowledge, of the distinguished French geologist, its author, to the utmost.

M. Delesse is naturally desirous that this map should be known to American geologists, and to receive from them, directly or indirectly, such criticisms of it as will enable him to improve it in future editions.

THE GLACIAL EPOCHS.

By Eli K. Price.

(*Read before the American Philosophical Society, March* 3, 17, *and April* 3, 1876.)

The Geologists speak of the Glacial Epoch, with a ready confidence that implies they consider it an admitted doctrine of their science; and they mean by "the glacial age," one of continental ice sheets. Glacialists have written large volumes on the subject, and its literature is swelling into a library. Agassiz, born and educated among the Alps, studied their glaciers and their effects, and traveling thence, applied his theories to other parts of the world. He was very sincere in his convictions, and complained that so few of his colleagues accepted his views; but in the confidence that he held a great truth he was willing to abide the coming of the time he foresaw, when Geologists would generally accept his theory. That time seemed to have arrived before he died, with some distinguished exceptions.

Those who have made Geological Surveys of England and Scotland, and parts of the Continent of Europe, either as conductors of public Surveys, or as Professors in colleges, or teachers through the press, find the ready explanation of what they see, in the doings of the great Glacial Epoch, when the supposed Northern ice-sheet filled the Arctic Ocean, the British and Irish Seas, and covered Northern Europe continuously over land, rivers, seas and mountains, to shed its icebergs far out into the Atlantic. And so too in this broad country, the Geologists who have made our public Surveys, who teach in our colleges, or publish, have generally read the rocks and drifts in the same way, in making explorations that have extended over the length and breadth of this continent.

Geologists, as other scientists, must follow the truth as the facts of nature compel them. Truth's compulsion is as inexorable as the pressure of the gigantic ice-sheets, these glacialists suppose, bore down from the pole. But they, as others, must often review their facts before they accept a theory as conclusive, and make themselves sure that they have not, by an engrossing attention to limited facts, overlooked others which should have influenced their theorizations.

They teach that the Glacial Epoch has occurred twice at least, since the rocks were laid in the strata as we see them; long after the coal measures were formed; of which the evidence is to be found upon the surface of the rocks as they now exist, and in the clays, and drifts, and boulders now spread over those rocks. Geologically speaking, these phenomena are of recent date, although before the Niagara began to cut the channel we now see. The astronomical cause assigned for them gives them a periodicity of about twenty-one, to twenty-two thousand years, and our northern hemisphere the respite of the half of such period, before it shall again be ground into paste.

We have the deepest interest, as a truth of science, to know what have been the causes that have deeply modified the surface of the world we inhabit; and a yet deeper interest in knowing what shall befall that part of the northern hemisphere now occupied by the most intelligent and civilized portion of mankind, with their wealth, cities, cultivation, and works of transportation and travel; for if the theory be true all these will be ground into the comminution of the boulder clay that flows from beneath the glacier of the Alps! When men pay for real estate they exact an extreme scientific care that they get a fee simple title forever, Why be so anxious, if all is to be razed, leaving them an interval of but a term of years. Yet more; we cannot but sympathize with a posterity destined so to perish; and with the shock to the faith of those who believe in a Creator, capable, and willing to conserve His creation.

Let us then see what this supposed continental ice-sheet is. Listen then to the very words of Agassiz, author of the theory: "It is a sheet of snow ten or fifteen thousand feet in thickness, extending all over the northern and southern portions of the globe; and must necessarily lead, in the end, in the formation of a northern and southern cap of ice, moving to the equator." Speaking of the northern, Agassiz further says: "As to the southward movement of an immense field of ice, extending over the whole north, it seems inevitable, the moment we admit that snow may accumulate round the pole in such quantities as to initiate a pressure radiating in every direction," "alternately thawing and freezing, it must, like water, *find its level* at last." "In the State of Maine, I have followed, compass in hand, the same set of furrows, running from north to south in one unvarying line over a surface of one hundred and thirty miles from the Katahdin Iron Range to the shore. These furrows follow all the inequalities of the country, ascending ranges of hills varying from twelve to fifteen hundred feet in height, and descending into the intervening valleys two or three hundred feet above the sea, or sometimes even on a level with it." (A Journal to Brazil, 403, 402.) These all are words of Agassiz, with no word of apprehension or sympathy for his fellow beings, for whose welfare the noble labors of his life were devoted.

Agassiz gives further explanation of his views on the "Ice period in America," in the *Atlantic Monthly* for July, 1864. The ice moved over the continent as one continuous sheet overriding nearly all the inequalities of the surface, p. 88. Fragments of rocks from Lake Superior are found in New England, and northern rocks on the prairies of Illinois and Iowa, down to the fortieth degree of latitude. Polished rocks and straight scratches may be seen for hundreds and hundreds of miles. The slopes of the Allegheny range are glacier-worn to the very top, with the exception of a few points. Mount Washington is over six thousand feet high and wears glacier marks to near its summit. Here the thickness of the sheet could not have been less than six thousand feet. If much lower than that the ice passed over the mountains. He asks us to imagine the climate of Greenland brought down to the fortieth degree of latitude, with ice thousands of feet thicker

than it is there at present. Norway, Sweden, Scotland, England, Ireland, were so covered, p. 92. This, it is true, was long ago; yet late cave explorations are supposed to indicate, that the latest glacial epoch was since man inhabited the earth.

Professor Winchell, adopting the glacial theory, states its causes and effects. He rather delights to make science sensational and astonishing. "The high northern latitudes experience an *unwonted uplift*. Arctic lands raise high their dripping heads above the temperate waters of the polar zone. The climate of the whole northern hemisphere feels the change. No moving currents can now bear torrid warmth to the frozen sea, and return the colder waters to the equatorial zone." "The snows of many winters are gathered on the slopes of Northern America." "Glaciers brood over all the land." "The marks of this stupenduous glacier are yet visible." "The northern limit was chained by eternal frost to its rocky bed. The southern only was free to move, and the whole expansion would be developed along the southern border." (Sketches of Creation, 214.) "From season to season, and from year to year, the mighty mass marched irresistibly forward, mowing down the forests, crushing tree-trunks, or burying them with the rubbish of the rocks, from ten to sixty feet below the surface." "The great glacier moves onward." "It bridged Niagara River; it bridged Long Island Sound, and bathed itself in mild waters of the ocean beyond," p. 218. 219. "It made a *tabula rasa*." River channels were filled up; "In Ohio and Indiana these buried river-beds are of frequent occurrence. The ancient gorge of the Niagara River was filled by the obliterating agency of this continental glacier." "It wiped out the trifling furrow, * * making it necessary for the river to begin anew its work," 219, 220. It bore rocks southward twenty, fifty, and even five hundred miles. "These fragments have been transported over lakes, sounds and seas." The glacial agency is not recognized south of the Ohio River, 220, 221. The south was spared; nay, greatly favored; for except the chain of mountains, the material ploughed up by the ice was carried by the waters to make the Cretaceous seaboard, the Gulf states and the many more of the Mississippi, and Missouri valleys.

This reign of ice came after the close of the carboniferous age, and after the land was upraised and dry, and vegetable and animal life existed on it as now, except that man was not yet here. Winchell is so speaking (219, 213), and then says, "Next in the order of vicissitudes was a grand continental subsidence. Vast areas of Northern America, that had been raised to the altitude of perpetual snow, were gradually lowered to the ocean's level. Again the interchange of equatorial and polar temperatures was affected by the moving sea-currents, and the climate of summer smiled over the desolate empire of frost," 222. "By degrees Wisconsin, Michigan, New York, Ohio and other Northern States disappeared beneath the waves," p. 228. "It seemed like a failure of the plan of creation. The land gained by *unnumbered throes* of the continent was lost. The higher summits only held their heads above the level of the careering

waves. Deposits bearing the marks of oceanic action reach to an elevation of six thousand feet on *Mount Washington, two thousand* or more on the Green Mountains, and *three thousand* on Monadnock. But this deep submergence was not of long continuance. Slowly the continent rose again from its deep sea burial," 229. Thus the continent here, as we shall see in Europe, seems to rise and fall thousands of feet at the bidding of theorists.

The Ohio Geological Report of 1873, written by Dr. Newbury, is equally threatening; 1 vol. 85: "The period immediately following the Tertiary age in geological history, but separated from it by we know not how many thousands of years, presents us with a complete change in the physical condition not only of our own continent, but apparently of the whole northern hemisphere; a change not exceeded by that which takes place upon our surface in the alternations of season from mid-summer to mid-winter. We have abundant evidence that during what is called the drift period the climate of our continent had changed from the all pervading warmth of the Tertiary to an all pervading arctic cold. While in the former age the climate of our Southern States was carried to Greenland, in the latter the *present climate of Greenland was brought as far south as the Ohio.* The continent of Greenland is now nearly buried under snow and and ice." "Precisely such must have been the condition of much of the North American Continent during the glacial period, for we find evidence that glaciers covered the greater part of the surface down to the latitude of 38 or 40 degrees." The smoothed and grooved rocks are covered with the glacial drift deposits; and upon and mingled with it, is the Erie clay; deposited from suspension in water and stratified; doubtless from basins where had been the retreating glaciers, p. 86.

If geologists did not produce so many restorations of the past, full of wonderful instruction, we would be apt to say that surely the imagination had large operation in making such confident explanations of the past doings of Nature upon this globe. Grand, sublime, were and are her operations; but one cannot help thinking if they could be seen that their progression was slow and orderly, without extreme vicissitudes, and as harmless as we now see them. There was ample time for the work; and Geologists readily allow any amount needful for observed effects, counting a thousand years as a day. The sedimentary rocks show that the process was generally a quiet one, the more modern with fewest faults; and certainly nothing could have been more carefully done, than the manner of the growth and storing away of the coal and oil, under their rocky coverings for the use of the human beings that were to occupy the world. Excepting the ventilating volcanoes, and the mountain-heaving earthquakes, the elevations and depressions of the earth have been at the rate of but a few feet in a century, so that it can hardly be soberly said that the land was gained by "unnumbered throes." Nay the probability seems to be that the concurring operation of the sinking of the sea beds and the raising up of the mountains, the one balancing the other, were then as now, only to be gauged by the lapse of the centuries, so quiet and imperceptible were they. Geology

has no chronology of years, but only of the order of its own successions, and the preparations, in the "beginning" of this earth, for man, there is every evidence was very long, and not violent.

James Geikie writes in more measured and careful language than any of those who have lately written on the Glacial theory; and he may, therefore, be allowed to be its reliable expositor. Writing "The Great Ice Age," he says, "We must believe that all the hills and valleys were once swathed in snow and ice; that the whole of Scotland was at some distant date buried underneath one immense *mer de glace*, through which peered only the higher mountain-tops. This is no vague hypothesis, or speculation founded on uncertain data, no mere conjecture which the light of future discoveries may explode. The evidence is so clear and so overwhelmingly convincing that we cannot resist the inevitable conclusion." p. 82. "Now the scratches may be traced from the islands and the coast-line up to the elevation of at least 3,500 feet; so that ice must have covered the country to that height at least." 83. Agassiz added one-third to the height scored, that the ice-sheet might have a back pressure to pass it over the elevations. "Such changes happened not once only, *but again and again*," says Geikie, 200.

Of North America, Geikie says, It is no exaggeration to say, that the whole surface, "from the shores of the Arctic Ocean to the latitude of New York (City), and from the Pacific to the Atlantic, has been scarped, scraped, furrowed and scoured by the action of ice." 411.

And the conclusion of Geikie's Great Ice Age is this. "Upward of 200,000 years ago the Earth, as we *know from the calculations of astronomers*, was so placed in regard to the Sun that a series of physical changes was induced, which eventually resulted in conferring upon our atmosphere a most intensely severe climate. *All Northern Europe* and *North America* disappeared beneath a thick crust of ice and snow, and the glaciers of such regions as Switzerland assumed gigantic proportions. The great sheet of land-ice leveled up the valleys of Britain and stretched across our mountains and hills down to low latitudes in England." And so it is said as to the north of Europe. "Ere long this wonderful scene passed away. Gradually the snow and ice melted; the arctic mammalia disappeared; the climate grew milder, until something like perpetual summer reigned in Britain. Then it was that the hippopotamus wallowed in our rivers, and the elephant crashed our forests; then, too, the lion, the tiger, and hyena became denizens of the English caves." Then after a "long time" it grew cold; these tropical animals disappeared, and the arctic beasts came back; but the climate became so severe that even these "migrated southward, *until all life* deserted Britain, and snow and ice were left in undisputed possession. *Once more* the confluent glaciers overflowed the land, and desolation and sterility were everywhere." "We cannot say how often such alternations of cold and mild periods were repeated." "A similar succession of changes transpired in North America." The palæolithic man was here in the inter-glacial period, and frozen out! 534, &c.

In Scotland "the direction of the scratches, ruts, and grooves upon the rock head, usually *coincides with the trend of the valley* in which the till occurs." Geikie's Ice Age, 21. "In the Northern Highland * * they keep parallel to the trend of the great glens; and in the Southern Uplands, likewise, they follow all the windings of the chief dales and 'hopes.'" p. 80. A hope is a sloping plane between ridges of mountains. Let us remember these local indications.

And James Geikie asks, "What do we learn from the erratics?" the far-traveled blocks over the whole face of the country. "The highland boulders on the Pentlands and Lammermuirs, for example, after crossing Strathallan or Strathearn, traversed either the Campsie or Ochil Hills, and passed athwart the broad vale of the Forth before they finished their journey. By what agent were they transported? The answer is by a colossal glacier." p. 223–4. "It is a fact that most, if not all, the *erratics* have traveled in directions that coincide with the *trend of the rock-striæ*." "The erratics lying loose upon the ground have moved in the identical direction, followed by the till of the same regions; a direction which it need hardly be said coincides with that of the underlying rock-striations. Indeed, when the *till* is carefully searched it not infrequently *yields fragments of the same rocks* as those of which the erratics lying *loose at the surface* are composed." 224–5. Mark how coincident with the topography.

He further proceeds to say, that after the great glacial deposits of Scotland, "the country at length became submerged to a depth in the south-east and west midland district of probably as much as 1,100 or 1,280 feet." 353, 255. "The river deposits of the lowlands were *now partially re-assorted*, or top-dressed, as it were, by the action of the sea. As the submergence approached its climax the temperature became colder; *ice-rafts floated about*, and *dropped boulders over the sea-bottom*. These are now found floating on the slopes of the reassorted gravels, and enclosed in stratified clays, the character of the shells in which prove the climate to have been severe." 353.

Mr. J. Geikie finds in England, Wales and Ireland the like evidence of glaciation, of depression of the land and inflow of the sea, and the elevation again of the land; but no true *till* has been found in east Anglia. 371. "The striæ upon the rocks, and the direction in which the till has traveled, mark out clearly the path taken by the great sheet of ice which wrapped up Ireland even as it enveloped Scotland." 373.

Scandinavia, Northern Europe generally, Switzerland, the Vosges, Black Forest, and Pyrenees, bear evidence of former Arctic conditions. "Even as far south as latitude 37°, the former existence of glaciers in the Sierra Nevada has been proved;" * * "and so on with most, or perhaps all, the hillier regions of Europe, great snow fields existed where now there are none," or but "insignificant successors." 379. And the like account is given on the testimony of travelers of Caucasus, Atlas, Lebanon, the Himalaya, and mountains in the north of China and in North America. "The direction of the glaciation in the extreme north of Scandinavia, the

peninsula of Kola, and Northeastern Finland demonstrates that the great *Mer de glace radiated outwards from the high grounds* of Norway and Sweden, flowing *north and northeast* into the Arctic Ocean and east into the White Sea, and thus clearly proving that Northern Europe was *not overflowed by a vast ice-cap creeping* outward from the North Pole, as some geologists have supposed." 382. These are Geikie's words; and here he is at issue with James Croll and Agassiz.

Geikie proceeds: "After that boulder-clay had been laid down, dry land appeared in Scotland and the north of England; and at a later date, a movement of subsidence ensued which resulted in drowning Wales to a depth probably of not less than two thousand feet." "All we know is that Scotland, Wales, and the north of England were largely submerged." Geikie, 479. The south and southeast of England was not submerged, and that portion only contained paleolithic instruments; but the neolithic occur everywhere in and throughout the British Islands; 480; and here were no traces of glaciation; 479; the line of division being the middle of England; 484. The islands and continent became connected; 485.

He says: "It is remarkable, that nowhere in the great plains of Siberia do any traces of glacial action appear to have been observed." Ib. 495. "Consequently we find the great river deposits with their mammalian remains, which tell of a milder climate than now obtains in those high latitudes, still lying undisturbed at the surface." 496.

In the regions of Alaska, west of the Rocky Mountains we have, says James Geikie, "a continuation of the same physical conditions that characterize the more northern latitudes of Asia, namely, great plains intersected by large rivers. Along the banks of these rivers, north of Mount St. Elias, numerous mammalian remains, especially the mammoth, have been detected." "But in the northern latitudes, east of the Rocky Mountains, no such mammalian remains have been detected." "They are rare also or altogether wanting in Canada." "Nevertheless, proofs are not wanting of a former mild condition of things having prevailed within comparatively recent times in the far north of British America." 497.

The glacialists generally find no cause for the great ice sheet, whose effects they see, in the elevation of the mountains, or in ice floods, nor in ice rafts floating from the pole. Mr. James Croll finds its cause in the earth's movement in an elliptical and eccentric orbit round the sun, which is central to one end of the ellipse, so that when the earth moves in the other end of the ellipse it is three millions of miles farther from the sun, and in the extreme of the orbital eccentricity he says fourteen millions of miles further from the Sun; and by reason thereof the warmth of the Sun is lessened at its surface. At this time the Earth is nearest the Sun at our mid-winter, and our winter solstice is supposed to be warmer for it; but by the precession of the equinox, the Sun crosses the equator twenty minutes and twenty seconds sooner than the year before; Geikie 129; by which process our seasons become gradually shifted in relation to the position of the Earth in its orbit, so that in ten thousand five hundred years our winter

solstice will coincide with the Earth's greatest distance from the Sun; 130; hence, greater refrigeration; and hence, according to Jas. Croll, a great ice cap at the North Pole; to be yet more aggravated when such coincidence shall occur at the greatest eccentricity of the Earth's orbit. It is not asserted that in any one year the Earth will receive any less heat from the Sun, or in either hemisphere than in the normal state of the Earth's movements. If the aphelion winter be colder, the perihelion summer would be warmer in the same hemisphere. At the present time these both occur in the southern hemisphere, and we hear of no abnormal cold, or increase of ice. Certainly South America is not invaded by ice, and our ships are going round Cape Horn as usual. It is not known that the glaciers on the Andes have grown higher or longer; while it is known that by the rise of Norway of but three feet in a century, the mountain glaciers have grown longer by about three hundred yards. The good people there need not be in a hurry to emigrate, for in due time the vertical oscillation will be in an opposite direction.

Agassiz says, in his Journey in Brazil, in proof of his opinion, "On my arrival in Rio de Janeiro, * * * my attention was immediately attracted by a very peculiar formation consisting of an ochraceous, highly ferruginous, sandy clay. During a stay of three months at Rio, whence I made my excursions into the neighboring country, I had opportunities of studying this deposit, both in the province of Rio de Janeiro and in the adjoining province of Minas Geraes. I found that it rested everywhere upon the undulating surfaces of the solid rocks in place, was almost entirely destitute of stratification, and contained a variety of pebbles and boulders." p. 299. "There can be no doubt in the mind of any one familiar with similar facts observed in other parts of the world, that this is one of the many forms of drift connected with glacial action. I was, however, far from anticipating, when I first met it in the neighborhood of Rio, that I should afterwards find it spreading over the surface of the country from north to south and from east to west, with a continuity which gives legible connection to the whole geological history of the continent." p. 400. "A sheet of drift, consisting of the same homogenous, unstratified paste, and containing loose materials of all sorts and sizes, covers the country." p. 403. Up the coast at Pará, he says, "I was surprised to find at every step of my progress the same geological phenomena which had met me at Rio," and he was reliably informed "that this formation continued through the whole valley of the Amazons, and was also to be found on all the affluents." p. 405. Now Rio is at the 24th degree of south latitude, Pará at one degree, and the Amazon discharges under the equator. Did then the polar ice cause the phenomenon? If so, was it by a mighty continuous land-borne glacier from the South Pole, or by ices from the Andes, glacial or floating? He gives no explanation here, but elsewhere regards the Andes as sources of the glaciation. He saw the unstratified paste "spreading over the surface of the country." Other geologists, in other parts of the world, find its supposed equivalent, the "boulder clay or till," at the bottom of the drift

formation, and long antecedent in deposition. But there is no reason why the paste should not be formed through all time, where there are mountain glaciers, grinding the rocks of the descending defiles, with a water underflow, frosts and rains, to spread it over the lower country, to an indefinite extent through indefinite time.

There certainly seems to be no warrant for the supposition of a polar ice-sheet over South America, while a cause for the phenomena seen seems much nearer. There are the Cordilleras, ever ice-covered, with valleys filled with glaciers grinding upon the rocks, and making paste or Till of their comminuted materials, and incessant freezings and thawings and rains to carry down the product over the *surface of the land*, now as well as when the first drift deposit was made. Further information is certainly wanted upon this subject, and it may be hoped that Professor Orton, now about to visit the Amazon, may afford it. Mr. Kerr, in his Report on the Survey of North Carolina, in 1875, makes observations pertinent and interesting: "Till or initial drift," which "may be seen everywhere on the hills and slopes of the Piedmont region, and less conspicuously, even in the eastern territory of the Quarternary proper." p. 157. "Evidently these materials" (the gold gravels) "have descended the slopes of the mountains and ridges, at whose bases, or on whose lower and gentle inclines they are found. By what force? Certainly not of water. Neither are they moraines; accumulations at the foot of descending ice masses. They are simply beds of *till*, which have crept down the declivities of the hills and mountains, exactly as glaciers descend the Alpine valley, by successive *freezing and thawing of the whole water-saturated mass, both the expansion of freezing and gravitation contributing to the downward movement;* and with each thawing and advance, the embedded stones and gold particles dropping a little nearer the bottom." p. 156. This idea may explain much of the appearances that perplex geologists, without driving them to the theory of an immense polar ice-sheet glaciation. All past time, since the mountains rose from the sea, gives room for normal causes to complete their work, with the results we witness; and account for Till being found upon the surface as well as beneath the drift, and that without a polar ice-sheet.

Those who concur in the conclusion that there have been continental ice-sheets of great thickness, and destructive of all life where they moved, are not agreed as to their cause, source, or extent. Agassiz insists that their cause is cosmic, and more than the normal glaciers of high mountains; and he and James Croll, and Winchell, and others, give them a polar center and a flow towards the tropics down to at least the 39th degree of latitude, and Agassiz extends them into the tropics. James Geikie, with Croll, ascribes to them an astronomical cause, but makes the mountains of Norway and Sweden the source and center of the ice-distribution. Winchell infers a mountain at the North Pole adequate to the production and movement hither of the great ice-sheet. This want of accord among these eminent glacialists is an argument of considerable force to show that the theory is without a tenable foundation.

Beside, the theory is so extraordinary, in its conjectured cause, and so stupendously disastrous in its consequences; and so wholly at variance with the ordinary procedures of Nature, that mankind have a right to take their stand on the stability of normal laws, and to demand the clearest and most indubitable proofs, before they yield their faith in all they have been taught by experience and history.

Uniformity between cause and effect; stability of law; are the basis and surety of all philosophizing. Building on such foundation mankind have believed that this earth is their stable habitation, since man was placed here, and that it is neither to be drowned nor ice-clad, to the destruction of the life upon it. We reasonably infer from all the past that the world was made to support the life it sustains; that the Power that could create both it and that life, and adapted one to the other, had a purpose of their permanence, and would not permit that purpose to become frustrate. Against such an inference, based in all knowledge of what has been, they who assert an impending liability to the destruction of half or more of the human race, with its wealth and civilization, have a right to demand an attesting example in the world's geological history, or reasons more cogent than seem to have been offered, to prove that such destruction awaits the world.

They have a right to say that so general a disaster is not compatible with the established order of the universe. Those who offer an hypothesis, the converse of this ground of security, have the burden of the proof and of the argument resting heavily upon them. The facts they rely upon must be clearly incapable of any other solution; the cause assigned must fit the effect.

All physicists profess to adhere to the normal laws of nature; as the law of gravitation, the movements of the planets, &c., the formations of the rocks, their elevations and depressions; of evaporations, and rainfalls, and congelations, &c.; and he who rests himself on such foundation is to be taken to be upon the true foundation, until it is clearly shown that some eccentricity of nature has been acting exceptionally, and has left the evidences of her exceptional action in manner to be incapable of explanation by her usual laws. Adhering to these laws geologists have generally agreed that in the beginning this Earth was very hot and that its interior was the source of igneous rocks; that it was surrounded by water and steam; and in the pervasive waters the sedimentary rocks were deposited from the eroded materials of igneous rocks, and by incessant repetitions of the erosions of both kinds of rocks, and that as late as the Carboniferous Ages the Arctic had yet a Tropical climate. By heat the Earth was kept expanded, but cooling by radiation it gradually grew less, and the crust of rock became too large for the internal mass, and consequently by its own weight the collapse sunk the valleys and raised the hills, formed the ocean beds and heaved the mountain ranges, and the Earth's rocky covering became plicated and corrugated, yet by a process as gradual and quiet as the radiation of the internal heat. This process was onward until its cause ceased; but the cessation of the radiation was no cause for a glaciation

greater than we witness. By the impulse that produced the rotation of the Earth on its axis, the shape of the globe was reduced from a sphere to an oblate spheroid, by the flattening of the Poles, and that cause forbade mountains rising at the Poles. It is necessary that we keep the above principles and facts in view as we proceed. The height of mountains, and seas open to the Poles are both causes of glaciation, and not to be overlooked, but cannot be cause of the continental ice-sheet.

Having stated the theory of the great glacial ice-sheet, and the facts upon which the glacialists place it, it seems expedient, considering how generally it has been accepted, to take yet closer and broader views of other facts and laws requisite to correct conclusions, many of them furnished by the glacialists themselves, but looked at by other eyes, these may afford proofs that should conduct to an opposite induction.

The *unstratified drift*, or boulder clay, or Till, is a chief argument for the continental Arctic sheet of ice. Grant it came from beneath ice, that fact does not prove that it came from a polar ice-sheet, for it might be from glaciers of contiguous mountains, or ices floating down from the North. Dr. Dawson say: "It may be viewed as consisting of a base or paste including angular and rounded fragments of rocks. The base varies from a stiff clay to loose sand, and its composition and color generally depend upon those of *the underlying and neighboring rocks*. Thus, over sandstones it is arenaceous, over shales argilaceous, and over conglomerates and hard slates, pebbly or shingly. The greater number of the stones contained in the drift are usually like the paste containing them, derived from the neighboring rock formations." Acadian Geology, 59. In Brazil it is "ochraceous, highly ferruginous, sandy clay." Agassiz, 399. This is evidence that the source of the Till is local and co-extensive with a local cause and source; but as the Andes are of immense height and running the length of South America and covered by perpetual glaciers, so the manufacture of the paste is present through all time; and the frosts and rains have ever since the Cordilleras were raised, spread it over the declining surface towards and to the Atlantic. With this eternal winter ever present upon the Andes, even under the Equator, it does not seem necessary that we should seek a cause in a great "cosmic winter," "of universal cold," which may have lasted "for thousands of centuries," for so much Agassiz says. We need not then go to a polar ice-cap for an explanation. The Till may be there from normal causes, and thus be yet spreading over the surface.

Agassiz rejects the idea of deposition under the sea, because there are no marine remains in the strata of rocks or their covering. He says: "It is my belief that all these deposits belong to the Ice Period in its earlier or later phases, and to this cosmic winter, which, judging from all the phenomena connected with it, may have lasted for thousands of centuries, we must look for the key to the geological history of the Amazonian Valley. I am aware that this suggestion will appear extravagant, but is it, after all, so improbable, when Central Europe was covered with ice thousands of

feet thick; when the glaciers of Great Britain ploughed into the sea, and when those of the Swiss Mountains had ten times their present altitude; when every lake in Northern Italy was filled with ice, and these frozen masses extended even into Northern Africa; when a sheet of ice, reaching nearly to the summit of Mount Washington * * (that is, having a *thickness* of nearly six thousand feet,) moved over the *continent* of North America; is it so improbable that, in this epoch of *universal cold*, the Valley of the Amazons also had its glacier poured down into it from the accumulations of snow in the Cordilleras, and swollen laterally by the tributary glaciers descending from the table lands of Guiana and Brazil? The movement of the immense glacier must have been eastward, determined as well by the vast reservoirs of snows in the Andes as by the direction of the valley itself. It must have ploughed the valley bottom over and over again, grinding all the materials beneath it to a fine powder, or reducing them to small pebbles; and it must have accumulated at its lower end a moraine of proportions as gigantic as its own; thus building a colossal sea wall across the valley." p. 425. But he found no striated stone as there was no natural rock-surface in the valley; and admits "I have not here the positive evidence which has guided me in my previous glacial investigations." p. 426.

All this account of the Amazonian Valley is inconsistent with what Mr. Agassiz had, in the same Journal, 403, said of a Northern and Southern Ice-cap "moving to the Equator," and with all the other glacialists who claim that it did not descend below the thirty-ninth degree of latitude. This gigantic glacier certainly did not come from the South Pole; nay, when in the stage of thawing, it did not move at all. It was dammed in by its own moraine or huge wall of *débris*; and when it melted it became a vast fresh-water lake. And Agassiz says: "In this shallow sheet of water under the ice, and protected by it from any violent disturbance, those finer triturated materials always found at a glacier bottom, and ground sometimes to powder by its action, would be deposited and gradually transformed from an unstratified paste containing the finest sand and mud, together with coarse pebbles and gravel, into a regularly stratified formation." Ib. 428. This is said to explain why this is not like the same glacial product in Europe; why it is stratified as a deposit of still waters, but does not explain how the same material has a different appearance over the general surface of Brazil; how the trituration and stratification would go on without motion of both ice and water, nor what, during such quiet lake-like operation under ice, had become of the floods that were ever descending from the greatest water shed of the world which must reach the sea. The attempted theory demands too much, involves difficulties not cleared up, and stands upon another basis than that of polar glaciation. That the floods of the Amazon and all its tributaries should be self-dammed into a lake of fresh water, and, at near the sea level, covered with ice under the equator is a proposition that seems of the most extraordinary nature, and self-condemning.

Let us proceed to examine other witnesses for additional facts, and compare other opinions of the scientific experts, though it be to find them expressing conflicting views, as they are wont to do in courts of justice, when it becomes the duty of the judge to extract the truth as well as he can, by principles of reason applied by good sense. The testimony will keep in view not only the facts of glaciation, but also those which show that there were other causes for all the phenomena we witness less abnormal than that assigned by the eminent naturalist whose name gave authority to all his utterances. If a continental ice-sheet of the magnitude supposed could not travel hither from the North Pole by land, there may have been water-ways for ice to float down from the Arctic region, and also local glaciers from higher mountains where none are now to be found, or those of much smaller size.

If the glaciation was cosmic, polar and continental, then should Northern Asia bear evidence of it. James Geikie claims to include North America, but does not claim Siberia as having been subject to the reign of ice. He says: "Thus, in the Western as in the Eastern Hemisphere, we are confronted with precisely the same phenomena. In regions which can be proved never to have been over-ridden by the great continental glaciers, and in districts which give no evidence of submergence during the latest period of glacial cold, the extinct mammalia occur in less or greater abundance at the very surface." Great Ice Age, 501. He further says the north coast of Asia "indicates the former presence of a milder climate in Siberia than now," "in the presence of numerous animal remains," as of the "mammoth, wooly rhinoceros, bison and horse." p. 495, 496. "The great plains of Siberia never could have nourished glaciers." "The absence of high grounds, and the comparative dryness of the climate, must have prevented any accumulation of glacier ice." 502. And he only claims that the great glaciers extended southward to the middle of England. Yet to fill the conception of Agassiz and Croll the ice formation at the North Pole should have so filled the Arctic Ocean as to move by its weight over the land of Northern Asia, as well as over Europe and America. The land journey should have been the same over the three continents from the same mountain of ice at the North Pole.

Next to the boulder clay, the scratches and groovings in the rocks are taken as the proofs of the Polar ice-sheet. Their straight northerly direction affords the argument.

Dr. Dawson, an eminent practical geologist, who has observed by travel and reflected much upon the subject, rejects the theory of the great ice-sheet from the far north. The scratchings are not from one direction, but some from nearly north, some from north 20° and 30° east, north 20°, 25°, 30° and 65° west. Acadian Geo. 62; 69. In the St. Lawrence Valley the direction is from northeast to southwest. At Stony Point, Lake Erie, Michigan, the grooves are from north 60° east, and from north 60° west. Winchell, 218. Dana gives greater variations, showing variations and hitches in the moving mass. 539, 751. And Henry D. Rogers said, the

grooves crossed at various angles, and "the striæ are, moreover, not rigorously straight, but curve slightly to conform to inequalities in the shape and hardness of the resisting surface." 2 Geo. of Penna., 775.

Dr. Dawson says: "I have no hesitation in asserting, from my own observations as well as from those of others, that for the southwest striation the direction was *from the ocean toward the interior*, against the slope of the St. Lawrence Valley. The crag-and-tail forms of all our isolated hills, and the direction of the transport of boulders carried from them show throughout Canada the movement was from northeast to southwest. This at once disposes of the glacier theory for the prevailing set of striæ, for we cannot suppose a glacier moving from the Atlantic up into the interior. On the other hand, it is eminently favorable to the idea of ocean drift." 69. This was based upon the idea of a submergence of Canada, New York, and New England, and an Arctic current bearing ice in the forms there produced. He proceeds to say: "Now we know that in the Post-pliocene Period, Eastern America was submerged, and consequently the striation at once comes into harmony with other geological facts." 70.

Dr. Edward Hitchcock, in his address in 1841, says: "The group named post-tertiary by Mr. Lyell, is found also in the northern part of New York and in Canada, containing shells of a more Arctic character than those now living in the same latitudes." p. 18. To produce the drift, scratchings, and transportation of boulders witnessed, the agents must have been water and ice, exerted before the existence of man on the continent; yet geologically recent; but he did not pronounce his belief in the great ice-sheet. 22, 23.

Professor Rogers says: "From the coast of Maine westward to the basin of Lake Ontario, and from the estuary of the Hudson northward to that of the St. Lawrence, a deposit of blue clay and sand occupies the valleys of many of the rivers at all levels above the tide and to a height of more than four hundred feet in the Valley of Lake Champlain, where its elevation is at its maximum." And speaking of the later local drift, he says: "No one general direction or northern source can be assigned to this upper deposit, *its gravel and erratic blocks appearing rather to be derived from the more ancient general drift of the adjoining hills, redispersed by some aqueous movement upon the surface of the fossiliferous clays and sands.*" 2 Geo. of Pa., 775.

To proceed with our survey geographically from east to west. The Geology of New Jersey by George H. Cook presents us with some relevant information. He says: "After the process of deposition had ceased, the whole of this ancient shore has been elevated to nearly four hundred feet above the ocean level. This has taken place bodily." But, "Some powerful agency like that of water, or water and ice, has swept over the whole country, and has worn down its surface in gullies, valleys, or broader intervals, sometimes to the amount of three or four hundred feet." p. 285. He gives twenty-four observations of scratches on the Traprocks. Of seven on the Palisades their course is south 20 to 40 degrees east; Bergen

Neck southwest and southeast; south and west of Patterson south 60 to 75 degrees west; Second Mountain and Rook Mountain southwest and 15 to 65 degrees west. p. 228. "The stones and boulders are in many cases from distant localities," those containing fossils are found in place only on the northwest side of Kittatinny Mountain. 229. "Two skulls of the walrus, an animal living only in the polar seas, have been found in the gravel near Long Branch." p. 342. These were, no doubt, ice borne; the question is whether by floating or creeping ice? Parts of South Carolina has undergone a similar denudation of one hundred and fifty feet. Tuomey's Gel. Rept. 102. All these are evidences of the doings of ice, and of currents of water from the northward, and not of the rigid movement, and grinding, leveling power of a gigantic ice-sheet.

British America, north of and including Canada, is generally a plane; its lakes being from three hundred to eight hundred feet in height; and the chain of great lakes bounding the United States are from two hundred and thirty-two to six hundred feet, the height of Lake Superior; so that the rise between Quebec and the west end of that lake, twelve hundred miles, averages six inches a mile. Survey of Canada, 1863, p. 6, 7. A table of one hundred and forty-five glacial grooves is given in the Survey of Canada, with a general southern direction, p. 890, of which eighty-four range west of south, some of them from 45 to 76 degrees, and fifty-seven range eastward, some of them from 45 to 80 degrees, or approaching an east and west direction. These are in Southern Canada, below 50°36′ of north latitude. Along the Ottawa the furrows conform in a general way to the direction of the river valleys, the limits of which appear to have guided the moving masses producing the present grooves." Ib. 889.

The superficial deposits in the vicinity of Montreal show former sea margins at the heights of 470, 440, 386, and 220 feet over the sea level. Dr. Dawson, Geol. Report of 1863, p. 918. Below the lowest level and about one hundred feet above the St. Lawrence, or one hundred and twenty above the sea, are the stratified deposits of gravel and fine-grained sand; then comes a calcareous gray sand, which rests upon the boulder clay, which is filled with rounded and striated fragments of various rocks, all of the thickness of about one hundred feet, of which the boulder formation is the greater part. The rocks beneath are polished and grooved. The boulders were drifted southwestward, and came from 40° to 70° east of north. Ib. —. Yet, towards the mouth of the St. Lawrence, a Gaspé boulder of limestone, 40 feet in diameter, has been moved several miles north or northeastward, and blocks of granite from Table-topped Mountain down Magdalen Valley several miles northeastward. Dr. Dawson described similar instances of northward transportation of boulders in Nova Scotia. Ib. 803. The White Mountains were at long distance of time twice elevated, first by a force from north 80° west, then from south 10° east, which indicates the thrusts of oceanic depressions from the west as well as from the Atlantic. See C. H. Hitchcock's Rep. to N. Ham. Leg. for 1871, p. 9. It is thus seen that Canada as well as New England and the Mississippi

Valley rose from the ocean, and at different elevations the abraiding ice had different directions.

By the Ohio Geol. Survey, vol. i, p. 538, it appears that of the striæ across the islands in the west end of Lake Erie and in the Maumee Valley, sixteen observations in eight counties, have a bearing south 80° west to 35° west with two intersecting grooves south 15° west. At West Sister Island the glacier moves westward, the pressure and planing being greatest at the east front, while on the opposite shore the undulating surface of the rock has been merely scratched. p. 539. The limestone rocks of that island contained imbedded flint nodules, which offered a greater resistance to the ice. On the "lee" side of each is a long ridge in the limestone by reason of the protection of the hard flint. This phenomenon, says Mr. Gilbert, "seems to afford a better explanation of the long, smooth, even furrows so frequently seen, than the theory that they have been engraved or ploughed by large boulders;" p. 540; that is to say, the rocks were ground by the ice.

Dr. Newberry describes the drift deposits of Ohio, and as to the lowest says, the "sheet of clay and boulders I have termed the Glacial Drift because it seems to be the direct product of glacial action." p. 86. Scattered over the drifts are numerous boulders, often of great size. They must have "been floated to and dropped upon their present resting places. In my judgment no other agent than *floating ice* could have accomplished their transport in the manner in which it has been done. Hence, I have considered them as the result of iceberg action, and have termed them and the northern gravel with which they are associated, the *Iceberg Drift.*" 87, 183; 2 vol. 4.

Pursuing the Ohio Survey into the second volume of 1874, Dr. J. S. Newberry gives many pertinent observations and reflections: "In Ohio we have no geological formations intervening between the Carboniferous and the Quaternary." The reason, "about the close of the Carboniferous Age the Allegheny Mountains were raised, carrying up all the area lying between the Mississippi and the Atlantic. From that time to the Quaternary no part of this region, with the exception of the southern margin, was ever submerged." "West of the Mississippi the land has been often and long below the ocean level since the epoch of the coal measures." "The materials which accumulated during the Quaternary are beds of clay, sand, gravel, and boulders, which have received the name of *Drift.*" "The drift deposits cover nearly all parts of the State." p. 1. He holds that the rocks were planed down to latitude 40 by glacial action. p. 2. The lowest drift deposit, "though not always present, is a tough, blue, unstratified clay, generally thickly set with small stones; more rarely containing those of larger size, ground and scratched;" hence, called the boulder clay. "In certain localities the pebbly 'hard-pan;' or boulder clay, is overlaid by a greater or less thickness of fine laminated clay, without pebbles;" and these blend so as to leave no line of demarcation, and together are called *Erie clay.* Above is the *Forest Bed.* p. 3. "In Western Ohio, In-

diana, Illinois, &c., the uppermost strata of the drift is called the Loess or Bluff formation." These "are the products of the last submergence, and I have termed them the *Lacustrine* Drift." Upon these "are scattered boulders and blocks of all sizes of granite, greenstone, silicious and mica slates, &c., &c., &c., generally traceable to some locality in the Eozoic area north of the lakes." "The boulders are found on nearly all the drift-covered area of the State; being carried over the summit of the water-shed, and reaching south nearly or quite to the Ohio. The margin of the boulder area seems to mark the outline of the great ice-sheet at the period of its greatest development; but *most of the boulders* strewed over this area, *appear to have been deposited by another agency*, at a much later date." They lie near the surface, often over purely laminated clay, "and hence could never have reached their present positions through the agency of glaciers or powerful currents of water. They must, therefore, have been *floated* to their present resting places. The evidence is conclusive that they were transported by icebergs, and hence I have called them the *Iceberg Drift*." p. 4.

Dr. Newberry gives 87 observations of a system of grooves confined to the lake basin and the northwestern counties of the State, from which he says "the prevailing direction of the stria is 10° south of west," and remarks "that in this portion of the State a series of glacial marks which have a nearly north and south bearing, are obliterated by the stronger, fresher, and more numerous grooves of which the bearing is nearly east and west. As I have shown elsewhere, the striæ which cover the highlands and southern portions of the State were probably made by the continental glacier which existed during the period of greatest cold, and which had in Ohio a movement from north toward south and southeast; while the glacier which moved from east westward in the lake basin was a *local glacier of later date*, and the one by which the excavation of the lake basin was principally effected." 2 Ohio, R. 10.

"It seems that in the period of greatest submergence the larger part of the summit of the water-shed was under water." "At this time a sufficient depth of water existed in the passes of the water-shed to float icebergs of considerable size, and as currents flowed through these passes, some of the boulders scattered over Southern Ohio were probably transported by them." Five of these passes are noticed; marked "by deeply excavated channels, now more or less perfectly by great accumulations of rolled and transported material, such as would be the natural product of a copious flow of water, continued through ages of time, and gradually diminishing and losing its transporting power." p. 47. These out-lets carried the waters southwestward into the seas or lakes of the great Mississippi valley. The Niagara River and Falls then were not. p. 52.

"The boulders belong almost without exception to the chrystaline and igneous rocks that are found *in situ* only to the north of the great lakes." p. 26. None are from east Canada or Labrador; but nearly all "can be traced to places of origin in localities north and northwest of Ohio." p. 27.

An inquiry here arises that if floating ice must have been the cause of all the drift and erratics, why should not the same cause have produced the boulder clay? The floating ice could as well do it, as it ground over the ledges of rocks, as an Arctic glacier and the water could better spread the clay as it is found. Such a supposition would obviate a resort to the great ice-sheet for explanation, and avoid other difficulties to be noticed. It is certainly an immense conception of an abnormal cause to explain a limited effect, that seems to have already had its sufficient and acknowledged solution in the cause of every other stratum of the drift.

It is said by Dr. Newberry (2 Ohio Rep. 29), "That the boulder clay was not deposited *beneath* the glacier, as sometimes stated, is apparent from the fact that it covers the glaciated surface on which the ice rested, in a sheet sometimes a hundred feet in thickness. *It must, therefore, have accumulated at the margin of the glacier.*" As the boulder clay is very widely spread, as well as often of a great depth, the more natural inference would seem to be that it was spread by the waters, as ground from the rocks by floating ice-rafts, and afterwards yet more dispersed by the ocean currents. But the witnesses do not always agree with themselves or with each other upon this subject.

The 2 Volume of Ohio Rep. in its Chapter L., contains views at variance with the theory of "the glacier," contributed by Mr. E. B. Andrews. He says Professor Hopkins expresses the belief that the boulders found on highlands of the 2d Geological district, were transported by floating ice-rafts, "and not by a vast, continuous northern glacier," and that drift materials were carried down to the lower Mississippi district. And Professor Hilgard thinks that "the phenomena observed in the Southern States are but the necessary consequences and complements of the drift phenomena of the North," and says it is time "that the Ohio should cease to be proclaimed as the southern limit of the drift." p. 451. Mr. Andrews speaking of the southeastern part of Ohio says, we have seen "there is no evidence that the pre-glacial or ante-drift surface *was essentially different from what it now is.* If there was a climate so arctic in character as to allow of the extension of a sheet of ice immensely thick almost to the Ohio River, we should expect that the same cold climate would necessitate glaciation in the Allegheny Mountains, but a short distance south of the Ohio, where no traces of glaciers have been found. The average altitude of the Allegheny range is 3,000 feet. If, on the other hand, the cold were produced by marine currents coming down from the Arctic region, it would have the sharp limitations characteristic of such currents at the present day." "Local glaciers are freely admitted to have existed on the higher grounds adjacent to the icy northern currents." p. 449. Mr. Andrews quotes the strong views of the Duke of Argyle, President of the Geological Society of London, against the glacial sheet, as satisfactory. p. 450.

In the Geological Survey of Illinois, of 1873, the northwestern section is described by James Shaw. He says, "That vast glaciers of ice once extended over large portions of North America is now universally conceded.

Their slow, crawling motion and irresistible force ground the rocks to powder, as wheat is ground to flour between the upper and nether mill-stones; not only ground them to powder, but rounded and polished the boulders and the gravel, planed and grooved the rocky surface of the earth, and moved the vast masses of drift materials from place to place in slow procession." 5–6. "But the great mixing and transporting agency which arranged, assorted, and deposited our Northern Illinois drift deposit, was evidently *the mixed action of ice and water.*" 6. The first and greatest force was the glaciers of the high lands; "then the floating iceberg and ice-field produced by their results, carrying the large boulders from place to place, and dropping them over the ice-cold seas; and last, the wave and current forces of water, after the ice had in part, or altogether melted, left loose clays, sands and subsoils, substantially as we find them now." 6–7. "Eroding and denuding influences have removed from three hundred to three hundred and fifty feet of Magnesian limestone and shales." "The dynamical powers of heavy bodies of water and water currents, and other drift forces, must have acted long and powerfully in bringing them about." 31, and see 32. "A mixed mass of gravel * * would seem to indicate that forces from a distance and forces near at hand, operating in every conceivable direction, with great force and over long periods of time, all contributed to gather together these heaps of abraided materials, some from the distant regions of the granite and the traps, and some from the neighboring limestones of a bygone geological age; but all equally worn smooth by the grinding of the waters and ice." 109. "Whether the floating iceberg, or the slow crawling glacier, or the strong water currents, or all these combined, transported the coarser materials of the drift, the force of the powerful agents were much modified in their action here." 145. It would seem that the other powerful causes stated, might suffice, if "the slow crawling glacier were omitted; and this is the opinion of Mr. E. B. Andrews; assistant in the Ohio Survey, 2 Vol. 447. He says, "There is no general planing off of the rocks; but everywhere among the hills where the northern boulders are most abundant are projecting knobs or outliers of soft rocks, which would naturally be an easy prey to such a destructive force as would be exerted by the movement of a vast glacier." 448.

Moving westward we reach Wisconsin, Iowa and Minnesota, upon which David Dale Owen made his Geological Report, to the U. S. Government in 1852. Among the materials of the drift the "trappean rocks are much the most common." "They originated at the time of the upheaval of the trap, and at comparatively a recent period. There are facts ascertained which render it probable that a large area of the Northwest Territory has been raised during very modern periods, even since the present fauna inhabited its rivers and lakes." "There is a gradual drainage of its waters taking place, even at this time." p. 143.

"In the vast prairie region of Iowa, the attention of the geologist is frequently arrested by erratic blocks of enormous dimensions, scattered here and there, and half sunk in the ground." "They are far from their

original situation." "The only explanation that is at all satisfactory in accounting for the transporting power which has brought detached masses of granite rocks into their present position, *is floating ice*; ice drifted by currents setting from the north, before the land emerged from the ocean, in the same manner as, at the present time, thousands of tons of rocks are precipitated on the bed of the Atlantic Ocean from icebergs." "Their isolated position in the prairie also indicates that they were dropped into their present positions rather than rolled into it." 144, 145. "The clay-beds are often thinly laminated, at some exposures, the laminæ are wrinkled. They conform in their dip to the general undulations of the country." p. 298. This, of course was after the depositions.

Charles A. White's first annual Report in 1867, to the Iowa Legislature, speaks of meeting with some striæ on the bluffs which border the bottom lands of the Missouri River; the coarser set (No. 1), S. 20° E.; the finer (No. 2) S. 51° E. Set 3 below Omaha is S. 41° W. p. 144. The direction of the scratches No. 3 observed coincides pretty nearly with general direction of the western watershed of the State; "and sets No. 1 and 2 respectively represents currents approximately coinciding with the general courses of the Missouri and Platte Rivers." p. 145. Diversity in the direction of the grooves, passing from all northerly to all southerly points, and in conformity with the trend of valleys and water-sheds, favor the theory of the cause being floating ice rather than the rigid gigantic ice-sheet that would hold its course onward against all obstructions, according to the glacial theory.

Professor Hayden has occasionally noticed the action of ice during his recent explorations in the far west, but the striations have been mostly from the valley glaciers in the mountains. He says: "Along the Platte River, below Omaha, and on the Missouri, near the city, the carboniferous limestones have had their upper surface so thoroughly smoothed by glacial action that they can be quarried out and used for caps and sills without any further finish of them." Report for 1870, p. 99. "There are a few small grooves or scratches, and * * I ascertained their direction to be about 27° west of north." All the limestones round Omaha, under the yellow marl and pebble deposits, were so smoothed. "In the mountains proper, the evidences of glacial action are not uncommon, especially on the sides of the deep valleys and gorges, but the causes were local and operated when the temperature of the climate was much lower than it is at present." p. 100.

Speaking of the eastern portion of the Rocky Mountains, source of the Arkansas, Professor Hayden says: "Perhaps the most interesting and novel features of this region are the great morainal deposits, the remains of ancient glaciers. These proofs of glacial action occur everywhere along both the east and west sides of the great Sawatch or Mother Range. But up the valleys of some of the side streams the morainal deposits are more marked and regular than in others." Report for 1873. Speaking of the Park Range, the gentle slopes are on the east side, the west sides very

abrupt, sometimes the rocks overhanging indicating that they are a portion of an anticlinal. Ib. 39. So our Appalachians and Atlantic seaboard hills lean from the Atlantic Synclinal, as if the upheaving force was in the sinking bed of that ocean, or as one preponderated in the balance the other rose.

One other great feature of structural geology is to be noticed in these Reports. The mountains are built of granite, gneiss, &c. From the Mississippi and Missouri to the Rocky Mountains the stratified deposits of sandstones, limestones, shales, slates, and clays, lie in flat broad sheets, "much as they were when first laid down, one after another in the *bottom of the vast ocean which once existed here.* Since this ocean was gradually drained off, the ceaseless action of the rains and rivers has in places removed thousands of feet of these rocks, exposing beds which were once deeply buried, and in which we can occasionally find the remains of shell-covered beings which still earlier lived and died upon the ocean bottom, or of the skeletons of the animals and plants which peopled the surrounding shores, and were swept by the ancient rivers out into the sea to be buried with the then forming sediments." Dr. Hayden's Report for 1873, p. 93.

And Dr. Newberry, in the United States Report for 1870, says of the lakes that once occupied the region immediately east of the Rocky Mountains: "The sediments that accumulated in the bottoms of these old lakes show that in the earliest periods of their history they contained salt water, at least the sea had access to them, and their waters were more or less impregnated with salt, so as to be inhabited by oysters and other marine or estuary mollusks. "In due time the continental elevation which brought all the country west of the Mississippi up out of the wide-spread cretaceous sea, raised these lake basins altogether above the sea level, and surrounded them with a broad expanse of dry land." p. 329.

But how came such "continental elevation?" Not alone by lifting up the continent bodily, else would the marine deposits have remained at the top and the waters have been drained off, carrying off largely its deposits; but must have been largely raised up by the degradation of higher lands or mountains by freezing, thawing, and erosions, and the flow of the materials into the basin of such sea and lakes, thus preserving both the salt and the fresh water fossils found there in "wonderful" abundance. So were Ohio, Indiana, and Illinois, filled and raised up, and hence, old river bottoms are found far beneath the present surface. And the stratified rocks thus formed have been since cut down into cañons, and even the granites also; all disintegrated both by frosts, heats, and erosive waters, and ice, as well as chiseled by "sand blasts." Hence are there many rocks left perched in the west as in the east, that have never been lifted, or floated by ice, but have simply held their positions after the surrounding strata had been carried away by the above named dynamic causes.

Dr. Newberry further testifies that, "In the progress of the Cretaceous Age, the greater part of the continent west of the Mississippi sank beneath the ocean, and the deposits made during the later portions of the Cretaceous

Age, contain a vegetation more tropical in character than that which preceded it. It seems probable that at this time the lands which existed as such at the west of the Mississippi, were islands of limited extent, washed by the Gulf Stream, which apparently had a course north and west from the Gulf of Mexico to the Arctic Sea." Prof. Hayden's Geological Survey of Wyoming, &c., for 1870, p. 336. It will not be forgotten that the tropical vegetation spoken of, was due to the warmth of the Gulf waters flowing to the northwestward, and perhaps, the Earth's interior heat, yet unradiated.

As by the discrimination made in the west by which all the drift above the boulder clay is ascribed to *floating ice*, so by the same rule the sand and boulders of New England should be ascribed to the same cause. They should be regarded as water-rolled and water-borne in ice rafts as they appear to have been, when existing mountains there were at different heights, and where the lower ridges were not so high nor the valleys so deep as now, and all but the highest mountains were under water, so that the excoriations would be the more continuous, and the rocks lifted from one ridge be carried upon another or dropped intermediately; reaching Long Island and the sea, or let fall at Stonington, or in the Sound and bays. Thus they might have been carried to ridges now higher, without violating the law of gravitation, as the latter may have risen disproportionately, as did the White Mountains compared with the Green. In Ohio, Indiana, and Illinois, they had not such mountains to guage the rise of the land as in New England, by the water level, as shown by the grooves of transported ice, but the water at the west left the proofs that it was the agent that shaped the surface of the country more perfectly than the ice-sheet would have done. Dr. Newberry speaking of the five gorges in Ohio, that gave outlets to the water towards the southwest, says: "Each of these gorges is now more or less filled with drift, but the remarkable similarity of level which they present will strike the most casual observer, and will not fail to suggest their reference to *a common producing cause*. All the lines of drainage leading southward from these passes are marked by deeply excavated channels, now more or less perfectly filled by great accumulations of *rolled and transported material*, such as would be the natural product of a copious flow of water continued through ages of time, and gradually diminishing and losing its transporting power." 2 Ohio Rep. p. 47.

Dr. Newberry speaks of repeated vertical oscillations of the surface: says, "The withdrawal of the water of the last submergence of the drift took place slowly, and its progress was marked by periods of rest, and perhaps, of recession;" hence, the *Terrace Epoch*. Ib. 50. The ice period was one of an elevation of several hundred feet. It was followed by a water period and warmth; the continent five hundred feet below the water level. The first deposit of this period was the boulder clay. p. 6. This would seem to make it a deposit under water. Then came the laminated clays, on this came the forest and peat beds, which of course grew in the air. After these may have grown for hundreds or thousands of years, a submergence

of the continent took place. During this, the *clays, sand, and gravel were deposited; floated down by icebergs from the Canadian highlands*, with blocks of granite, greenstone, slates. See p. 7. Yet "the glacier" is credited with having carried large blocks of lime and sandstones "one hundred miles or more southwest to points several hundred feet above their place of origin," from the north or islands within Lake Erie. p. 29. In view of all the circumstances it would seem more natural to infer that these large stones were transported by floating ice-rafts and deposited on ground that was *afterwards elevated*, as it often was by an interior force.

Again, Dr. Newberry says: "At the commencement of this ice period this continent must have stood several hundred feet higher than now." 2 Ohio Geo. Rep. 6. That the first product in Ohio of the ice period, was the boulder clay. And that in New England and other countries where granite and other silicious matamorphic rocks abound, the product of glacial erosion is sand, gravel, and boulders. As the great ice sheet retreated northward it thrust out and left behind it a succession of heaps of boulder clay which now form a nearly continuous sheet over the glaciated surface," Ib. These quotations present some difficulties. If the continent was several hundred feet higher at the commencement of the ice period than now, so much greater would have been the difficulty for ice to come hither from the Pole by land; whereas if it was then under water, as under the next coming drift period, such a rise was unnecessary to account for the Till which might be the product of floating ice; that would also dispense with Mr. Winchell's mountain at the Pole to make an incline for the ice to come down by gravity. And, again, it is not perceived how a northwardly retreating ice-sheet, that is, retreating only because and as it melted, could have *thrust out* and left behind it the boulder clay, bearing all the evidences of having been spread out and deposited under the action of pervasive waters. Indeed, Dr. Newberry seems to have raised the continent once oftener than necessary, if the boulder clay could have been deposited under the sea as he admits the drift and many boulders were.

Now, seeing from all the testimony cited, that Canada and all directly to the north, was under the ocean; New England also, except the highest tops of the mountains; and the great Mississippi Valley was also an extension of the Gulf of Mexico; that there were no great Mountains northwards of Canada, nor in Canada, but an ocean current bore thence southward dividing southeastward over New England, and westward and southwestward over the country lying between the Rocky Mountains and the Alleghanies, what is so likely to have been the source of the Till, the boulders, the drift, and rock groovings as the northern ice borne upon the northern oceanic currents? There may have been icebergs broken from Arctic Mountain glaciers, and other ice formations; all floating as ice rafts, thick and of irresistible momentum, grinding upon ridges yet under water and carrying their materials southward.

In view of the preceding facts it seems sufficing to say, that when New England, the Hudson and Champlain Valleys, Canada and the British

Possessions, Ohio and states west and southwestward were under water, and the currents and ices of the Artic Ocean had full sweep over those areas, we have the conditions to account for all the phenomena witnessed. without resorting to the extremely abnormal cause of a continental ice-sheet. The depression of New England Professor Winchell speaks of in this wise: "The higher summits only held their heads above the careering waves; deposits, bearing the marks of oceanic action reach to an elevation of six thousand feet on Mount Washington, two thousand or more on the Green Mountains, and three thousand on Monadnock." p. 229. If these measurements had the same sea-datum then their differences record the differences of the mountain depressions, or rather the elevations they had then attained. The same height on Mount Washington is that given by Agassiz as the highest elevation of the ice excoriation; Journey, 425; and that being the greatest ocean height, the conclusion is clear, that it was the edge of ice-sheets that made them, and these could only be floating ice; certainly not stones in the bottom of a continental ice sheet. The inference must further be that as the sea thus registered the greatest depression, or want of elevation of *each* mountain, Mount Washington had been four thousand feet lower than the Green Mountains, and three thousand feet lower than Monadnock; so that there was such depth of water over the valleys and plains as that the Arctic Sea could flow over them, floating either ice-bergs, or belt, or surface rafts of ice. The land it was that was unstable, while the sea kept its level. The supposed gigantic ice sheet needed not to be fifteen or ten thousand feet, or so many hundred feet in thickness, to make those mountain grooves, when the mountains stooped nearly to the level of the sea, or their tops had but peered above the water. All were not equally low, otherwise the highest grooves in all would have had the same level. And so a continental ice-sheet moving on the land already elevated should have scored them at nearly the same level; in either way showing that the mountains had not been sunk equally, or that they had risen unequally. The submergence of New England, with an open interior sea to the pole certainly shows an easier way of accounting for the ice grooves upon the mountains, than to raise a land mountain at the north pole, and an ice-mountain upon the top of that, with a refrigeration to keep the sheet of the thickness of ten to fifteen thousand feet in the "Granite State."

While there are the ice grooves of New England and elsewhere to be accounted for; and these sharply cut, and geologically recent, there seem to be other things visible on the surface quite incompatible with the supposition of a continental glacier of the thickness imagined. The hills of New England, under such a power should have been more leveled down; for a glacier kept hardly frozen could not have much viscosity; it should have crushed the stones into the *moraine profonde*; should have carried few angular erratics, for the mountains to furnish them would be "few and far between," with comparative small elevation. But what do we see there? Huge boulders; rocking boulders; perched up rocks, that would not have been there after such a planing with the gigantic polar-ice plane; and a

surface covered with water-rounded stones of every size and kind, which had to be gathered into stone fences before the soil could be reached for cultivation; yet so rounded are they that they readily roll out of place, though the base of the enclosure be broad. These are the natural product of a water-covered surface; of waters floating ice; which ice may have been thick as Greenland hummocks' ice-belt ice, or glacial icebergs, borne on the arctic current that now comes southward along the eastern side of our continent. We see the evidences that as the ocean retired, the elevation made successively of every part of New England a sea-lashed shore, leaving the drifts that the waters had spread over the sea bottom.

The glacialists seizing upon the one seemingly sufficing adequate cause of a great ice sheet, overlook the difficulties which that theory must encounter to account for that cause, and also other means that may more naturally account for the seen results, without resorting to any abnormal freak or eccentricity of Nature. They may notice that the grooves very generally conform to the trend of the high valleys and water-sheds and to the course of the currents when wide areas were beneath the sea; denoting the descent of mountain glaciers, or the transportation by water of ice-rafts, or icebergs. They refer not to the transporting power of water in times of ice-floods, when mountain sides slid down, and lakes broke through their moraine dams. They take the presence of irregular boulders in the under clay of the drift as the sure evidence of the work of the polar ice-sheet, while the presence of the like boulders in all the drift, as we see here in Philadelphia, is not taken as proof that all the other strata of the drift had the like cause. The heavy boulders they see at a higher level than their parent place *in situ*, they suppose could only reach their elevations by being pushed up by the great continental ice-sheet because it must obey the pressure of the great ice-head at the pole, and approximating the level of that source of pressure, rises over the secondary mountains of New Hampshire, the Katahdin of Maine, and bridging sounds and inlets of the seas passes into the Atlantic. It is overlooked that those boulders may rest on elevations that may have risen out of the sea from a lower level than the parent quarry; or may have been shoved higher by the back currents of water that will drive ice-sheets high upon each other when they encounter obstruction; while on the other hand the ledges of rock that yielded the supply may have sunk lower, by the earth's oscillations, or have been ground down by floating ice, after higher rocks had been carried away.

It is said the glacial epoch was so recent that the mountains were already so degraded as to be near their present height when that epoch come on, and could not have been cause of the effects seen. Now the last glacial epoch is placed many thousand years ago; Geikie says more than two hundred thousand years. We will not hold him to exact figures; but take it that was near the time, then it appears to have been ample for the mountains to become reduced from a much higher elevation than their present size, by the operation of normal causes, but anciently acting with greater activity. Now in every year since they rose the height of the

Alps has been lowered by causes that have never for one moment ceased; and yet more rapidly have the glaciers. which never ceased to flow, worn more deeply their channels. The striæ made by the ice on the sides of Monte Rosa and the Bernese Alps show that the glaciers moved at higher elevations relatively to the scored rocks, and adhering to the causes named, we must conclude that the mountains were higher and broader to increase the supply of snow, and that the glaciers moved upon a higher plane, whereby they scored higher tracings on the rocks, and projected further into the valleys below, and carried their boulders to a greater distance. These are causes sufficing for the visible effects, when we add to them to the transporting power of ice-bearing floods, carrying down land slides, and ice-covered lakes, which burst the dams that had sustained them. We need not go to the north pole or the planets to explain the phenomena of the Alps; except as icebergs floating down from the north would bring an arctic cold with them.

Lyell says "the Alps have acquired four thousand, and even in some places more than ten thousand feet of their present altitude since the commencement of the Eocene period." 1 Prin. 256. He speaks of what they *retain*; but what height they had at their greatest exaltation no one can tell, for upheaving elevation and disintegrating degradation are generally simultaneous proceedings; but from facts observed it seems more reasonable to infer that great glaciations were mainly local, except as arctic currents came down upon Central Europe freighted with ice.

Dr. Hector's statements lately made before the Geological Society in London, have a bearing upon several points of this discourse. The South Island of New Zealand has its Southern Alps of which Mount Cook, fourteen thousand feet high, is the highest, with a snow-field of one hundred and sixty square miles, in south latitude, nearly 44°. Judging by the moraine matter, snow formerly was vastly more abundant. He "demonstrated the excessive action of glaciers in cutting back cols; an action more energetic formerly; some of the cols having been worn down as low as eighteen hundred feet." "The reason for this contraction of the ice area is the great question for determination. Was it due to difference of climate, the result of a great glacial period? The remains of a past fauna afford no evidence of this. We may, indeed, suppose that the whole fauna migrated to the north; but we must, in that case *invent* the land and bring into play oscillations more extensive than those required for another alternative, viz:—the alteration of level, within the area itself. We might suppose a general alteration of level, even to the extent of four thousand feet higher than the present, but the evidence afforded by the shore line is unfavorable to this view. There remains the theory of *unequal elevation*, which combined with a most enormous destruction, the result of ages of glacier action, best explains the phenomenon." "In conclusion, the author stated his belief that there has been no general change of climate, but many changes of *relative level*, resulting in a great destruction of surface, which had taken place in groups of peaks at *different times*." Nature, January 27th 1876, p.

259. This statement is refreshing for its moderation and good sense. The isolation circumscribed the phenomena and forbade extraneous speculations.

Yet it is believed, that if we do look into general causes, and consider them well, we shall find that the forces of nature are so well balanced, that the imagined continental polar-ice sheet must be regarded as an impossibility; shall find that we need not raise mountains at the poles, against the effect of the force of the Earth's rotation, to slide down the ice; nor to submerge mountains and continents once elevated from the sea, again and again, to account for marine remains, or ice scratches upon the rocks, left there as they first emerged from the waters.

The theory of a north polar ice cap, spreading as a garment to the tropics, or to the fortieth degree of latitude only, seems not to have sufficiently considered the nature of the Arctic ice and climate. I open Dr. Kane's second Grinnell Expedition, and find that it wintered in Smith's Straits, latitude 78½°. In January the thermometer ranged from 64° to 75° below zero, Vol. 1, p. 154; from March 10th to 14th, the average was 46½° below zero. "The intense cold approximates all ice to granite." Vol. I, p. 184. Look at the pictures; the ice is as hard and sharp of outline as unworn rocks. p. 162. The glacier that has shed its iceberg presents a vertical front; The ice-belt between the "floe" and the land, is "24 feet in thickness, 65 in mean width; the second, or appended ice 38 feet wide; and the third 34 feet. All three are ridges of immense ice-tables, serried like the granite blocks of a rampart, and investing the rocks with a triple circumvallation." Ib. p. 162.

Dr. Newberry, 2 Ohio Rep. 70, cites Dr. Kane's account of a sheet of ice, eight feet thick, resting on supports twenty feet apart, as having swagged five feet midway of the supports, while the weather was far below freezing point, to prove that the polar ice-sheet could flow southward. To one not wedded to that glacial theory the evidence does not seem so strong. With the weight of its own bulk on the centre of a span of twenty feet, we might believe there was a perpendicular pressure much more than proportionable to the force that propels the Alpine glacier. Yet in several months the strain caused no fracture of the ice; no fluxion of particles to change its form; but all except the bend remained of the some shape, and sharp of outline. If it had rested on a plane of the inclination of the bed of the Alpine glacier, there is no indication that its mass or particles would have moved a hair's breadth. It will here not be forgotten that a polar ice-sheet to be thousands of feet thick in New England must be of growing thickness all the way to the pole, and that the intensity of cold for all that distance must have been greater than any Arctic cold known to us, and have held the ice formed in the water as firm as granite, and impervious to any heat that could reach it.

As to the snow that should fall upon land at a period of intense and long continued cold as supposed, it would not form into ice, or make the theoretical continental glacier. To make the ice of the moving glacier, there must be a back pressure from a greater elevation, and an *alternation of heat*

and cold; a thawing and regelation; so that climate may be too cold to make glaciers. Thus in Upper Thibet, on the north side of the Himalayas, the mean limit of perpetual snow is not only higher by more than a thousand feet than on the south side, but the belt of snow is narrower, the back pressure is less, and the snow deposited from the dry winds of Northern and Middle Asia are so dry as to make it questionable whether there are any proper glaciers, or anything more than the *névé*, or dry masses of snow in in layers. Reclus, 165–6; Professor Vogel, in Nature, March 16th, 1876, p. 394. Yet the snow there is seventeen thousand to nineteen thousand feet high, with a northern aspect.

Tyndall shews that ice is not viscous; will not stretch, but is brittle and will break under a strain, as when the glacier is compressed into a narrower channel; or must make a descent or curve; when the continuity is kept up by a back *pressure* and regelation; freezing then becoming an agency in wedging forward the mass in its shearing and descent. (Hours of Exercise on the Alps, 356, &c.) Yet under *pressure* it conforms to the valley and descends as if it were plastic. Ib. 358, 359, 401. To consider the difference between Tyndall and James D. Forbes, who held the theory of viscosity, is not now material. They both were dealing with the glacier in its cradle on the side of the Alps, having an inclination of four to five degrees, with a heavy incumbent pressure of the higher glacier, having a length of twenty or thirty miles, a width from two or three miles where widest; in one instance contracting from two thousand to 900 yards, with a depth sometimes of six hundred feet. Yet the downward flow was so slow as to require nice instrumental means to detect it, and though variable, owing to the difference of inclination, or choking of gorges, the figures for the day of twenty-four hours, most usually found are from twelve to twenty inches. 1 Lyell, 365, 366, 367. The flow is slower in winter than summer, and faster at the centre than the sides, and at the top than at the bottom.

It is apparent that the circumstances are not parallel with the supposed ice-cap at the North Pole. The existing testimony is, that this is an open sea; and if not that, is an ice covered sea, without land. There is not even level lowland for the ice to form upon. There is no mountain to bring the force of gravitation into operation. The ice that could saddle the pole could have no tendency to move in any direction, for there is no inclined plane. The hard frozen ice would not be borne downward by the weight of higher ice; nor crevices be filled by regelation, thus to wedge forward the frozen mass, as in high mountain regions. Greenland is a ridge of three thousand to four thousand feet elevation, and that will make glaciers in the valleys. But the supply of ice thence, or from Grinnell Land, or Labrador, to reach Europe, must have been *floating* masses; and so as to the interior of our country, if they came so far.

Ice is, in another respect, less likely to descend by land to a lower latitude from the pole, than if resting on a solid plane. Though the ice at a very low temperature would not melt in the air, yet, *resting on the water* it would become *sodden*, rot and sink; and without land support could not

rise to a height to spread the mass outward by its *own* fluidity, or any pressure of impending weight of ice. The point of least resistance would be the sodden ice and water beneath. The fresh ice contains no salt; the "water sodden," is "thoroughly infiltrated with salt-water." 1st Kane's Grinnell Expedition, 96. Captain Richard Wells, commanding the whale Ship Arctic, wrote to Mr. Grinnell, June 18, 1867, that he had steamed up Smith's Sound to about 79° of latitude; found the ice "rotten and very much decayed, the ship steaming easily through rotten floes. The ice on the east side, excepting in Whale Sound, appeared to have decayed away and parted from the land as far as the glass would carry, and would offer no impediment to the progress of any steam whaler. A poor foundation this, upon which to build a mountain of ice.

And consider also the geography of the Arctic region as to the proportion of sea and land, and the interposing elevations of the land. Remember, also, that the earth's features at the supposed glacial period were in outline the same as now. A polar ice-sheet to cover North America and Northern Europe must have filled the ocean to the bottom and risen to a height far above the sea to compel the ice to move by pressure southward to the 39th or 40th degree. We need not estimate what that height must be, when we know it would have no land basis to rest upon; and know also that intermediate mountains, indeed all land, would be obstructive of progress instead of sources of power. In Europe, such a polar ice-sheet must have filled the Arctic Sea, and risen from its bottom over the mountains of Norway, Sweden and Scotland. In North America it must have risen over the mountains of Grinnell Land, that of Greenland, and the Labrador and Laurentian ranges, and crossed the St. Lawrence River. But glaciers under pressure would sooner squeeze through a gorge, as two thousand yards in width will pass through a defile of nine hundred yards in the Alps. The channel of the Atlantic would be preferred to the elevated land to travel southward across fifty degrees of latitude by land. The continental ice-sheet would have been a glacier in the Atlantic. That the north polar sea is open, is not only proved by men who have looked upon it, but Dr. Scorsby testified that the "Right Whale" that always shuns the tropics, has carried the marked harpoon from Baffin's Bay, through Behring's Strait, into the Pacific; and the whale must breathe the air. He could not cross the equator, nor go under ice into the Pacific, Maury's Ph. Geog. of the Sea, Sec. 144. The birds go to the north of Greenland to breed because there they find their food in an open sea; and we know that northwest of this continent the Arctic Ocean extends down to the seventieth degree of latitude.

Again: Concede the extreme glacialists solid land at the pole for the ice-cap to rest upon; yet consider the enormous demand made upon our credulity to meet the conditions of their theory. The ice-sheet is to be from ten to fifteen thousand feet thick in New Hampshire, according to Agassiz: It is to reach the fortieth degree of north latitude according to several other glacialists. To give it the pressure by gravitation of the glaciers

of the Alps it must rest upon an inclined plane of four and a half degrees descent; or have such an elevation at the pole in its own thickness as to be equivalent to that inclination; and that would require a height of ice at the pole of two hundred and seventy-one miles, that the sheet might reach the fortieth degree of latitude. The statement of such requisition seems sufficiently condemnatory of the theory.

There are laws of limitations ever ruling all nature, including the powers of the air. These all have their boundaries they may not pass; their effects cannot transcend their limited cause. When we consider and perceive that no glacier or polar ice-sheet can be formed without snow, we must also perceive that the quantity of snow must find a limit in the heat that evaporates the water into the air that shall fall as snow. Create the Arctic climate over the world, that is requisite to maintain the supposed great ice-sheet unmelted, and you cut off the amount of evaporation necessary to form and preserve that ice-sheet. You have thereby made it an impossibility. To diminish the Sun's heat is to cut off the supply of snow to build the great glacier. Tyndall on Heat, 206. "We cannot afford to lose an iota of solar action; we need, if anything more vapour; but we need a condenser so powerful that this vapour, instead of falling in liquid showers to the earth, shall be so far reduced in temperature as to fall in snow." Ib. 207. That condenser must be *the mountains*, or be the polar cold. But the supply of *heat* from the Sun is ever a *constant quantity*. "This expenditure, (of the Sun) has been going on for ages, without our being able, in historic times, to detect the loss." Ib. 434. It is a supply ever dispensed; never spent, never varied; and will not permit the growth of the great ice-sheet. Less heat would make less snow, and snow must make the ice-sheet or glacier.

The theory supposes the ice-sheet to reach below the 40th degree of latitude; and the cold influences of that would extend over the world. There would not only be a failure of evaporation to fall as snow to maintain the ice-sheet; but the snow formed *could never reach the pole*, or approximate it, to form the head and pressure to drive southward the continental glacier The evaporated moisture of the tropics would be precipitated in snow as soon as chilled at the freezing point first reached; that is, as soon, at least, as it reached the ice-sheet. We find such to be the law of snow precipitation on the highest mountains. "According to Tschudi the quantity of snow which falls upon that portion of the Alps which is above 10,800 feet is comparatively very small. Most of the clouds charged with snow flakes discharge their burden on the mountain slopes at elevations of 7,000 to 8,000 feet." The Earth; by Elisée Reclus, 163. Mountains in Thibet 20,000 feet in height are therefore found denuded of every particle of snow, because the dry winds there have not the moisture to dispense in snow; and for the same reason the north side of the Himalayas have the lower snow line higher than that on their south side, where the heat is greater and the moisture more abundant. Ib. 165–6. Hence also there is an *upper*, as well as a lower snow line on very high mountains. Speaking of

Mer de Glace and the Mer d'Aletsch, Reclus says, "It is a very remarkable fact, in regard to both these glaciers, and those of the Himalaya, that the ice-rivers are much longer and more abundant on the southern side of the mountain than on the colder slopes which are turned to the north. This phenomenon must evidently be attributed to the larger quantity of snow brought by the south wind, and impeded in its course by the lofty mountains." Ib. 211-2. Thus the most snow comes from the side where there is the geatest heat for evaporation.

Dr. Hector shows that the same phenomenon takes place in New Zealand as in the Himalaya and other mountains; namely that the snow fall is greatest to the windward, whenever the temperature is at freezing point: "Much of this enormous precipitation is deposited as snow in the Southern Alps, which *comb* out the moisture from the westerly winds; hence the extensive glaciers of the mountain region and the comparative dryness of the Canterbury Plains." Nature, Jan. 27, 1876, p. 259.

As the climate of the world now is, the greatest quantity of snow does not approximate the pole, though it will last longest there. It is more abundant below than above the fiftieth degree of latitude. In British America, above that degree six days of snow in a winter, and a depth of three and a half feet, are normal quantities. 9 New Am. Cy., 327. With an ice sheet down to 40 degrees of latitude the deepest snow would probably be midway between the equator and pole.

There is, therefore, no cause of the continental polar ice-sheet found in the air; nor is there any effect of it seen under the earth, where the effects should have been often seen, if it proceeded from a planetary cause, for then it should have been of periodical occurrence, and the effect have been seen in fossils in the rocks. Since land first peered above the waters to yield disintegrated material for the deposit of the sedimentary strata, the rocks have kept the registry of every species of plant and animal, and thus recorded the temperature of the globe, and told us that the time was when tropical plants grew on the shores of Greenland. There, on the east coast are the Carboniferous slates and coal, and on the west side of the Island of Disco, at latitude over 69°, are impressions of the rankly growing vegetation of the tropics. The succession of stratified rocks, as arranged by Lyell in his table in their order of deposition, number thirty-eight, 1 vol. 135, commencing at some period of that long "beginning," when the earth was first in preparation for man's inhabitancy. No stratum of all those rocks tells of an ancient glacial period, while they all proclaim that the Earth was a constantly cooling sphere, that it might become fitted for the home of human beings. This process of cooling must have followed that uniformly diminishing rate with which a hotter body radiates its heat into space, with the local exceptions made by mountain elevations, the distances of the poles from the Sun's direct rays and by ice-bearing ocean currents. And certainly the Sun has in no period of the past dispensed less heat to the Earth than now. If there be any fact on, or within the Earth, or without it, to prove the contrary of such inductions from normal causes, it

is to be shown, not conjectured, not invented. We are not to be permitted to explain a difficulty by an imagined cause that involves tenfold greater difficulties. This they seem to do who make the induction of a continental polar ice-sheet, such as the glacialists describe it, with the vividness of those who might have seen it. Though their subject be glacial they write with a fervor that betrays an enkindled imagination.

James Croll emphatically invokes an astronomical cause for the Glacial Epochs; but the astronomers have expressed adverse opinions. Humboldt. (4 Cosmos 460) thus quotes Poisson on the Stability of the Planetary system: "It follows from the theorem of Lambert, that the quantity of heat which is conveyed by the Sun to the Earth is the same during the passage from the vernal to the autumnal equinox as in returning from the latter to the former: The much longer time which the Sun takes in the first part of its course, is exactly compensated by its proportionately greater distance, and the quantities of heat which it conveys to the Earth are the same while in the one hemisphere or the other, north or south." Humboldt also quotes Arago on Excentricity: "As the excentricity always has been, and always will be, very small, the influence of the secular variations of the quantity of solar heat received by the Earth upon the mean temperature would appear also to be very limited." If these opinions be true we must look to earthly causes; and not to the Earth's orbital excentricity produced by conjunction of planets in the heavens, or variable heats from the Sun.

There is, however, one cause besides the elevation of the mountains, and the inter-continental influx of the Arctic Sea, whereby the temperature of Northwestern Europe, may at sometime, have been greatly reduced, and that without any cause at variance with the normal physical laws. We have shewn many proofs why there was a central ocean between the widely spreading systems of mountains of the Eastern and Western parts of North America. It may hence have been that the waters heaped up by the Earth's rotary motion, and the trade winds into the Gulf of Mexico, found a passage through that inter-continental sea; and were not, as now, compelled to find their exit by Cape Florida and the Atlantic Ocean, to reach and warm Western Europe. Dr. Dawson did not suggest such a cause for such effect; but said what would truly be the consequence of such cause when he said, "any change that would allow the equatorial current to pursue its course through to the Pacific, or along the great inland valley of North America, would reduce the British seas to a boreal condition." Dawson, 79. The fact shown, the induction is legitimate and inevitable; and seems to be proved by established isothermal lines, shewing how greatly the gulf-stream mitigates climate.

How then are we to account for a past period of glaciation, of whatever intensity, greater than at the present time in certain places. We may do it without invoking abnormal causes. An adequate cause exists within less than five miles of every foot of the surface of the earth. Within that limit, with land elevation to the height of the upper snow line, and breadth to hold an adequate *Mer de Glace*, yet with a sufficient declivity to put the

ice in motion by gravitation, we have all the conditions necessary to account for all the glaciation and glaciers of which we find the traces in every country. That the greater glaciers have had such cause seems apparent from their effects remaining where the glacier ice left them. Within reach is ever the producing mountain, or was the open sea to the Arctic. These are sufficing causes for all we see within the range of the causes. The grooves of greater glaciers are seen in parallel lines at great heights on the mountain sides of the glacier-valleys, where glaciers now are, and in thousands of places where they have ceased to be; and there are the *moraines*, and the rocks *moutonné*, rounded and scored rocks in place, and those transported, all having an exact relation to the moving cause. The Earth by Reclus, Ch. 36. These are the certain proofs that the mountains have been greater, and the evaporation not less, but probably much greater, when the Earth was warmer. For these a continental or polar ice-sheet would in no wise account. It is not needed and is an unfitting explanation of the boulders spread so widely south and east of the Baltic, and even over Scotland, Wales and England; and such degree of cold may have been so induced by mountain elevations and Arctic sea currents as to invite Arctic animals and plants southward and to drive other animals further south. "It is now beyond all question," says Reclus that the numerous lines of rocks which are found here and there all over Northern Russia have proceeded from the granite mountains of Scandinavia. When an immense sea extended over Finland between the Baltic and the Polar Ocean, the blocks of ice which fell into the water that washed the base of the Scandinavian mountains, drifted away in flotillas towards the southeast to the shores of the continent opposite. The prominent angles of the granite blocks contained in the masses of floating ice have traced out long furrows over all the points and projections of the rocks in Finland, which was then only a marine shoal. M. Nordenskiöld has ascertained that almost all these lines of erosion tend from the northwest to the southeast, and that all the rocks with which the icebergs have come into contact are polished on the side which faces toward Scandinavia, while on the other side they have in every case retained their uneven surfaces, their projections and their clefts. With regard to the boulders themselves, they are all more rounded by friction the more distant they are from the Sweedish mountains of which they once formed a part." Ib. 219. And the same effects are there yet taking place, on a smaller scale.

During the winter of 1862–3, immense masses of ice, coming from Finland, were cast upon the southern coast of the gulf, and thrown upon the land a distance of more than three hundred yards from the shore, and to a height of thirty feet above the level of the sea. The ice which was forty to fifty feet deep, overwhelmed many dwellings and whole forests. In the latter large quantities of stones were subsequently found, which the ice left when it thawed. Reclus, 219, citing Keyserling and Von Baer.

The Danish Professor, Dr. Forchhammer, relates a striking fact to show that large quantities of rocky fragments are annually carried by ice out of

the Baltic. In the year 1807 he says, at the time of the bombardment of the British fleet, an English sloop of war, riding at anchor in the roads, at Copenhagen, blew up. In 1844, a trustworthy diver found the space between decks entire, but covered with blocks from six to eight cubic feet in size, some heaped on others; and he found all the sunk ships he visited thus loaded with rocks. 1 Lyell, 382. Now when the Baltic sea was opened to the north pole, and when much of Europe south of the Baltic was below the water level, there was the same condition there as has been shown to have been in North America; namely, an open sea to bear down ice-rafts from the north to supply the drift and boulders that are found spread over both countries, bringing with them a cold atmosphere.

The most recent account of the drift on the eastern side of North Wales, by D. C. Davies, F. G. S., gives us his conclusions: "1. The majority of the deposits are of local origin, being derived from the mountainous regions of North Wales, then an Archipelago of islands. 2. But from the plentiful admixture of foreign matter, he infers *an open sea* on the north. 3. He insists upon the necessity of *aqueous conditions*; the coast would be partly ice-bound, but *there was no general ice-cap.* Besides the general alterations of level there were *local alterations of level.* Proofs of this were to be seen in the neighborhood of Oswestry, beyond which town the Scotch granites do not seem to pass. This the author considered due *to currents* deflecting the *ice-rafts*, &c. Nature, Feb. 17, 1876, p. 318.

Let us be reassured, then, of the safety of Europe and North America, and the world. The Creator, we may believe, did not create the best parts of this Earth and plant there the highest civilizations ever seen upon it, with purpose of its utter destruction. These countries in Europe and America are the hopes of the race, with means of execution, now presented, as they have never been before. There is a uniformity of law, and stability in Nature, that justify man's confidence in the ruling of The Supreme Power, and that He is good. They who most profoundly study His works are the most thoroughly convinced that there is no eccentricity or caprice in His Rule; that He is "The same yesterday, and to-day, and forever." The oscillations of the Earth have become almost infinitessimal; the vertical vibrations as measured by the temple of Jupiter Serapis have not exceeded thirty feet; many volcanoes have been sealed up and people live securely within the rim of former craters; the Valley of the Mississippi will never again be an ocean's bed; the Gulf Stream will continue to mitigage the climate of Europe and preserve its genial temperature; and the Earth continue to turn upon its axis, and to revolve in its orbit, without a tremor; without a moment's loss or gain. God's balance wheel belts this Earth; and He gave to our globe those impulsions in its rotation and orbit which will forever precisely counteract its weight, and maintain its motions with such exactness as will keep all true time forever. Such momentum was given once forever. If not so, then God is forever sustaining His creation.

This earth has never, and upon the certain evidence of Geology, will never suffer a cataclysm. The faults of strata are limited and local; the

surface is fashioned by exterior agencies that level, smooth and beautify the world, and fit it for man's use and enjoyment, but which can never mar the sublimity of the cataract, or the majesty of the mountains; many of these crowned with never wasted snows. Some volcanoes yet burn to relieve the earth of the throes of its internal heat and gases, and to tame the earthquakes; yet are the latter sufficing agencies needed to raise the mountains commensurately with the degradations of the disintegrations and erosions of prevailing frosts, heats and rains. None of these, however disturb the general movements of the earth in its orbit, or on its axis, by the slightest vibration, or cause the delay of a second in time in its annual revolution. The Supreme Ruler has taken into the account every cause, and provided against disturbance, in advance; or at every moment keeps all things adjusted to absolute truthfulness. The cooling and shrinkage of the earth's crust, would upon mechanical principle, shorten the radius of the earth's axis, and hasten its rotation, and shorten the day; but as Humbolt says, this is provided against by the celestial movements being adapted to the thermal condition of our planet; and "from the comparison of the secular inequalities of the Moon with the eclipses observed in ancient times, it follows that since the time of Hipparchus, that is, for two thousand years, the length of the day has certainly not diminished by the hundredth part of a second. The decrease of the mean heat of the globe during a period of two thousand years, has not, therefore, taking the extremest limits, diminished as much as $\frac{1}{500}$ of a degree of Fahrenheit." 4 Humboldt's Cosmos, 168.

Some scientific men, and some that may not be truly such, seem fond of writing sensationally, to disparage the creation and to alarm mankind as to the stability and permanence of our planetary home. Andrew Wilson, in giving his travels in "The Abode of Snow," or Himalaya, in the first page of his preface suggests that it is not "an improbable theory that when the accumulation of ice round the south pole has reached a certain point, the balance of the earth must be suddenly destroyed, and this orb shall almost instantaneously turn transversely to its axis, moving the great oceans, and so producing one of those *cyclical catastrophies*, which there is *some reason to believe* have before now interfered with the development and civilization of the human race." One supposes, of course, the traveler to be playfully jocose when he thus speaks to recommend his favorite Himalaya as a safe place of retreat; the Himmels or heavens of our Aryan ancestors; yet Professor Winchell in a work of science is even more sensational, and has several serious chapters upon the inevitable progress of Creation to its ruin; in chapters headed "The Reign of Universal Winter," "The Sun Cooling off," "The Machinery of the Heavens Running Down;" and quotes Helmholtz as saying, "The inexorable laws of mechanics shew that the store of heat in the sun must be finally exhausted." And thus the author of the article "Force," in Chamber's Encyclopedia, gives his views of the finality: "This, then, it appears, is to be the last scene of the great mystery of the universe, chaos and darkness, as 'in the beginning.'"

Either then, the universe has been subjected to laws to make waste and decay impossible, and all things that undergo change are preserved in quantity and energy to preserve the whole forever in balance; or there is a Power that ever renews them; for we see that creation does not wax old, but that equal quantities of matter and force remain ever operative without detection of a moment's pause through thousands of years; without the loss of an atom of matter, of force, of heat, or light, without a discord, or tremor in the harmony of the Universe.

Adhering strictly to the Baconian canon of philosophy, to which all philosophers must be held; that is, to proceed only on well ascertained facts, and thence making inductions only in accordance with the laws of nature, also ascertained as facts, it is submitted that it will not be found that creation is ever growing weaker, is not verging to decay and annihilation. The more we shall know, the more profoundly we shall consider, the more surely shall we be reassured that this earth is not to perish by ice, or water, or fire; that the force that holds the systems of suns and planets in their rotary movements will never abate; that suns will not burn to cinders, nor their heat and light be spent or extinguished. And by the observance of the same canon of philosophy, of certain ascertainment of facts and strictness of induction, we must also infer from all creation, and creation's laws, that it had an Author to give it law, who wills to conserve it for ever; Him of whom we truthfully say, "Thy law is the Truth:" By, "Thy faithfulness shalt Thou establish the very heavens."